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SVIC NOTES

Many technical meetings are held each year which would be of interest to the shock and vibration community; I would like to discuss two such meetings that I recently attended.

The Fifth World Congress on the Theory of Machines and Mechanics which was held at Concordia University in Montreal Quebec, July 9-13, 1979 was extremely interesting because of a combination of a large international participation and the number of papers that described approaches to the solution of "real world" shock and vibration problems.

During the course of the meeting there were many sessions devoted to vibration or dynamics. Some of these covered biomechanics, analytical techniques in vibration, machinery noise, turbomachinery problems, rotating machinery and the dynamics of mechanisms. In addition many papers were presented on the characteristics of mechanical components such as bearings, cams, gears, and linkages. The proceedings of this congress contains over 300 papers in two volumes; copies are available from ASME.

The second meeting of interest, the ASME Design Engineering Technical Conferences, was held in St. Louis, Missouri, September 10-12, 1979. This series of conferences included the 7th Vibration Conference, the 5th Design Automation Conference, and the 3rd Failure Prevention and Reliability Conference. Most of the vibration related papers were found in the vibrations conference, although such papers could also be found in the other two conferences.

Over half of the sessions in the Vibrations Conference were devoted to machinery vibration problems, including sessions on vibrations of rotating machinery, blade vibrations, machinery noise, and mechanical signal analysis. One of the mechanical signature analysis sessions was a panel session on the challenges and potential of mechanical signature analysis.

Sessions on structural dynamics and finite element analysis were also programmed. A sample of the topics that were covered include the vibration of beams or plates, accurate stiffness and mass matrix reduction techniques, the application of minicomputers to finite element analysis, and the use of a programmable calculator for determining the mode shapes and natural frequencies of systems.

In all, over 100 papers were presented. Many of these will be published in the Transactions of the ASME Journal of Mechanical Design.

R.H.V.

EDITORS RATTLE SPACE

MORE ON TECHNICAL INNOVATION

An editorial by R.L.E. in the March 1979 issue of **The Shock and Vibration Digest** discussed the decline of technical innovation in the United States. The primary reason advanced for this decline was that we have become a "cautious, demanding-our-return-now, low-risk society." This societal attitude has resulted in a plethora of governmentally enforced rules and regulations designed to protect society from adverse technological impacts. These rules and regulations, in turn, cause costs to skyrocket and hinder the introduction of technical innovations into the marketplace. As a consequence, many promising ideas and innovations are probably killed prematurely.

The above conclusions accurately identify several societal symptoms that have affected technical innovativeness in the U.S. However, the more important questions of what causes and how to treat the causes of these symptoms are left unresolved.

Unfortunately, the principal causes of these symptoms reside within the technical community -- including scientists, engineers, manufacturers, and even technical regulators -- itself. We have systematically destroyed the faith of U.S. society -- including the technical community identified above who, for the most part, have limited competence in fields other than their own -- probably not so much in the value of innovation, but in our abilities (or in our desires) to rigorously justify, manage, and apply innovation and to predict or expeditiously react to adverse consequences of innovation. Examples range from the mundane, such as microwave ovens that needlessly emitted dangerous levels of radiation and hair dryers containing asbestos; to the more serious, such as unreliable automobiles with safety defects and nuclear reactors; to the potentially disastrous, such as nuclear weaponry and pollution of all forms. Hence, society justifiably places external controls and regulations on technological innovation and, through the law of bureaucratic growth, the present state has been predictably reached.

Is there a treatment or is technological innovation in the U.S. terminally ill? The answer in unknown.

R.A.S.

A REVIEW OF SUBSTRUCTURE ANALYSIS OF VIBRATING SYSTEMS

F.C. Nelson*

Abstract - This article contains a general review of substructuring; emphasis is placed on the method of component mode synthesis. Static substructuring is described as are dynamic substructuring by component mode synthesis and substructure truncation. Other substructuring methods are summarized.

The parallel developments of the finite element method and efficient numerical methods for high-speed digital computers have permitted engineers to undertake the solution of very large structural problems. Problems with more than 240,000 degrees of freedom (DOF) have been solved [1]. The techniques that allow such large problems to be considered are of interest to structural engineers. Perhaps the most common technique is the method of substructures. In this paper substructuring is reviewed, with emphasis on the method of component mode synthesis.

The substructuring method consists of three basic steps:

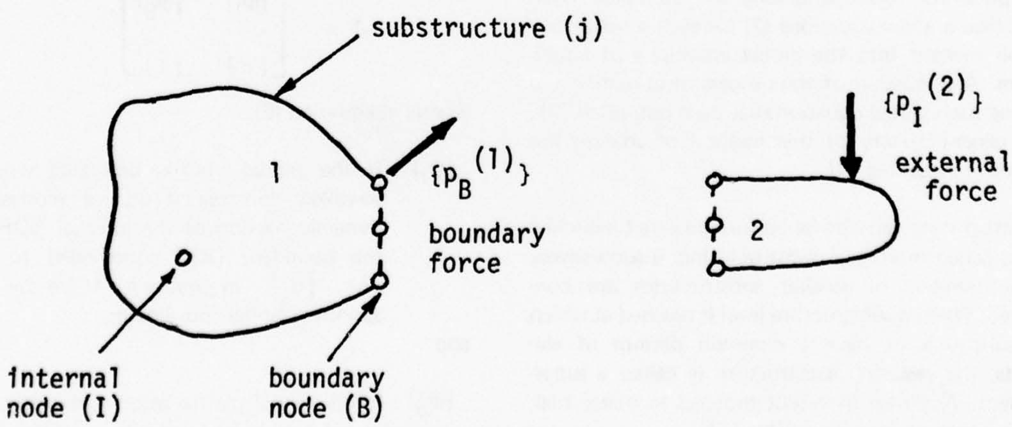
(1) Divide the global structure into a series of substructures. A reasonable process of division is to separate the global structure into a series of entities, each of which has a distinct function or geometry.

(2) Develop structural representatives for each substructure; for example, stiffness, mass, and damping matrices. These structural representations can be experimental as well as analytical.

(3) Assemble the substructure properties into global equations of motion and solve. It is in this step that large global structures can be handled. Replacement of high-order, global matrices with lower-order substructure matrices results in significant savings in computer storage and execution time. For example, for a piping system with 350 dynamic DOF, substructuring reduced computer costs by a factor of four [2].

STATIC SUBSTRUCTURING

Consider a global structure divided into two substructures



Substructure Notation

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The equation of static equilibrium for substructure (j) can be written and then partitioned according to the notation in the figure. This gives equation (1)

$$\begin{bmatrix} [k_{II}{}^{(j)}] & [k_{IB}{}^{(j)}] \\ [k_{BI}{}^{(j)}] & [k_{BB}{}^{(j)}] \end{bmatrix} \begin{Bmatrix} \{x_I{}^{(j)}\} \\ \{x_B{}^{(j)}\} \end{Bmatrix} = \begin{Bmatrix} \{p_I{}^{(j)}\} \\ \{p_B{}^{(j)}\} \end{Bmatrix} \qquad (1)$$

where k denotes substructure stiffness, x substructure DOF, and p substructure force. In this article, the substructure superscript -- (j) above -- is suppressed unless it is required for clarity.

The first of the partitioned equations in equation (1) can be used to eliminate $\{x_I\}$. This gives

$$[k_B]\,\{x_B\} = \{\bar{p}_B\} \qquad (2)$$

where

$$[k_B] = [k_{BB}] - [k_{BI}]\,[k_{II}]^{-1}\,[k_{IB}]$$

$$\{\bar{p}_B\} = \{p_B\} - [k_{BI}]\,[k_{II}]^{-1}\,\{p_I\}$$

Equation (2) represents a condensation of the stiffness matrix and load vector onto the boundary nodes; this process is called static condensation. If the boundary DOF are far fewer than the internal DOF, equation (2) will be of much lower order than equation (1).

Compatibility relations among the boundary DOF equilibrium allow equations (2) for each substructure to be merged into the global equations of equilibrium. A discussion of the process of obtaining and solving such global equations has been published [3]. The general theory of this method of analysis has also been presented [4].

Substructuring can also be performed on a hierarchial basis, called multilevel substructuring; a successively larger number of smaller substructures are considered. When a substructure level is reached at which all substructures have a common pattern of elements, the resulting substructure is called a superelement. A review of recent progress in hierarchial, static substructuring is available [5].

DYNAMIC SUBSTRUCTURING BY COMPONENT MODE SYNTHESIS

About 20 years ago the concept of substructuring was extended to the dynamic response of structures. The initial contributions were made by Hurty who called his method component mode synthesis [6]. Later workers, notably Craig and Bampton [7], developed component mode synthesis into a powerful procedure for the solution of problems in structural dynamics.

The equations for free vibration of a substructure can be partitioned into those associated with internal DOF (I) and boundary DOF (B)

$$\begin{bmatrix} [\diagdown m_{II} \diagdown] & [o] \\ [o] & [\diagdown m_{BB} \diagdown] \end{bmatrix} \begin{Bmatrix} \{\ddot{x}_I\} \\ \{\ddot{x}_B\} \end{Bmatrix} + \begin{bmatrix} [k_{II}] & [k_{IB}] \\ [k_{BI}] & [k_{BB}] \end{bmatrix} \begin{Bmatrix} \{x_I\} \\ \{x_B\} \end{Bmatrix} = \{o\} \qquad (3)$$

where $[k_{II}]$ and $[k_{BB}]$ are symmetric and $[k_{IB}] = [K_{BI}]^T$. Only lumped masses are considered in equation (3); however, consistent mass matrices can be employed.

Following Craig and Bampton, introduce the transformation

$$\begin{Bmatrix} \{x_I\} \\ \{x_B\} \end{Bmatrix} = [a] \begin{Bmatrix} \{q_I\} \\ \{x_B\} \end{Bmatrix} \qquad (4)$$

$$[a] = \begin{bmatrix} [\Phi_I] & [\Phi_S] \\ [o] & [I] \end{bmatrix} \qquad (5)$$

where, in equation (5),

$[\Phi_I]$ is the modal matrix associated with the so-called constrained normal modes; i.e., dynamic motion of the internal DOF with the boundary DOF constrained to zero. The $\{q_I\}$ in equation (4) are the corresponding modal coordinates.

and

$[\Phi_S]$ is the modal matrix associated with the so-called constraint modes; i.e., static motion

of the internal DOF due to unit value for one element of $\{x_B\}$ with all the other elements of $\{x_B\}$ equal to zero.

Substitute equation (4) into equation (3) and premultiply by $[\alpha]^T$ to obtain

$$\begin{bmatrix} [\,I\,] & [M_{IB}] \\ [M_{IB}]^T & [M_{BB}] \end{bmatrix} \begin{Bmatrix} \{\ddot{q}_I\} \\ \{\ddot{x}_B\} \end{Bmatrix} + \begin{bmatrix} [^\frown\omega_i^2\,\lrcorner] & [\,o\,] \\ [\,o\,] & [K_{BB}] \end{bmatrix} \begin{Bmatrix} \{q_I\} \\ \{x_B\} \end{Bmatrix} = \{o\} \qquad (6)$$

where $[M_{IB}] = [\Phi_I]^T [^\frown m_{II}\lrcorner]\ [\Phi_S]$

$[M_{BB}] = [^\frown m_{BB}\lrcorner] + [\Phi_S]^T [^\frown m_{II}\lrcorner]\ [\Phi_S]$

$[^\frown\omega_i^2\lrcorner]$ = the spectral matrix of the constrained substructure

$[K_{BB}] = [k_{BB}] + [k_{BI}]\ [\Phi_S]$.

Merge equation (6) for two substructures (i.e. the figure) to obtain the global equations

$$[M]\ \{\ddot{Q}\} + [K]\ \{Q\} = \{0\} \qquad (7)$$

where

$$\{Q\} = \begin{Bmatrix} \{q_I{}^{(1)}\} \\ \{q_I{}^{(2)}\} \\ \{x_B\} \end{Bmatrix} \qquad (8)$$

$$[M] = \begin{bmatrix} [I] & [M_{IB}^{(1)}] & [0] \\ [M_{IB}^{(1)}]^T & [I] & [M_{IB}^{(2)}] \\ [0] & [M_{IB}^{(2)}]^T & [M_{BB}^{(1)}] + [M_{BB}^{(2)}] \end{bmatrix} \qquad (9)$$

$$[K] = \begin{bmatrix} [^\frown\omega_i^{2\,(1)}\lrcorner] & [0] & [0] \\ [0] & [^\frown\omega_i^{2\,(2)}\lrcorner] & [0] \\ [0] & [0] & [K_{BB}^{(1)}] + [K_{BB}^{(2)}] \end{bmatrix} \qquad (10)$$

In equation (8) $\{x_B\}$ are the boundary DOF common to substructures (1) and (2).

The global equations (7) are well-banded and permit a variety of efficient solutions technique; for example, the global natural frequencies and mode shapes can be obtained. However, it is usually possible to obtain the desired information without assembling equation (7). Off-diagonal submatrices occur in the mass matrix, equation (9); however, it is possible to reformulate the problem so that this coupling is shifted to the stiffness matrix [8].

The above procedure can be extended to any number of substructures. Only the proper connectivities among the substructures must be imposed. Goldman [9] reformulated this procedure using substructure modal and spectral matrices based on free boundary DOF.

Substructuring permits a mixed analytical-experimental approach; e.g., in the Figure one substructure can be characterized by a finite element model and the other by experimental data. Klosterman [10] proposed a component mode method using fixed or free boundary modes and the measurement of stiffnesess, masses, and dynamic connection forces. Cromer and Lalanne [11] have applied the method to the determination of global frequencies and mode shapes of an actual structure. Their analytical experimental substructure predictions agreed well with the global experimental results for the lowest eight modes of a structure consisting of a cylindrical shell mounted to a flat plate.

Component mode synthesis can be used for the forced response problem as well as the free vibration problem. A formulation for forced response based on the state space approach of Frazer, Duncan, and Collar has been given by Hasselman and Kaplan [12]. This approach has been tailored to the case of a string of railroad cars coupled together to form a train [13].

The method of Craig and Bampton [7] was limited to undamped substructures. Hasselman's state space approach allows the incorporation of linear substructure damping in any form and in any amount. Simpler formulations are obtained for simpler models of damping. The possibility of using measured substructure damping to predict global damping has been addressed by Hasselman [14] and more recently by Jezequel [15]. Jezequel reported good agree-

ment between calculated and experimental value of structural damping for the first seven modes of a simple structure consisting of two flat plates joined at a right angle.

Substructure analysis by component mode synthesis has been extensively used in the aerospace industry. Other segments of industry have recently adopted it with considerable profit. In fact, it is the rapid success of this technology transfer that stimulated this review. Examples are available in the nuclear industry -- piping [2] and reactor core structure [16] -- and in the design of building and machine foundations [17, 18]. Soil-structure interaction analyses are of interest because the substructure equations are formulated and merged in the frequency-domain rather than in the time-domain.

A number of recent papers have applied modal synthesis to the design of rotating machinery. Shrouded gas turbine blades have been considered [19] as have shrouded steam turbine blades [20]. Shrouded blade groups are well suited to substructuring because each blade group is composed of an assemblage of identical blades coupled only at discrete points.

Glasgow and Nelson [21] considered a two-spool, rotor-bearing system. This paper is noteworthy because it indicates some of the complications inherent in the dynamic analysis of rotating structures. The inclusion of Coriolis effects in a rotating, vibrating structure produces a complex eigenvalue problem with an antisymmetric matrix and computational algorithms are not readily available. A review of the information available has been given [22]. To the author's knowledge, no one has thoroughly explored the numerical difficulties associated with modal synthesis using substructure matrices that are both complex and antisymmetric -- certainly an area in need of further research.

SUBSTRUCTURE TRUNCATION

In 1965, Guyan [23] extended the static condensation of a stiffness matrix to the simultaneous condensation of a mass matrix. His work was subsequently generalized and clarified by Kidder [24]. The procedure permits a condensation of the dynamic problem analogous to that achieved for the static problem. Guyan's reduction has spawned a variety of eigenvalue economizer procedures; a notable example is the master-slave method [25]. A recent study of the loss of accuracy arising from Guyan reduction and a systematic procedure for selecting master DOF is available [26].

In the determination of the natural frequencies and mode shapes of large dynamic models, it would seem logical to combine substructuring with condensation of the individual substructures. Leung [27] has presented a substructuring method in which the substructure boundary DOF are used as masters. For the case considered, a three-dimensional space frame, the combined method requires far fewer arithmetic operations than does condensation of the entire structure.

There is also a considerable amount of empirical lore in regard to substructure truncation. Rules of thumb have been suggested for the number of substructure DOF that must be kept to obtain accurate estimates for a given number of global natural frequencies. For example, Ramsden and Stoker [28] recommend that about 70 substructure master DOF be used when 20 global frequencies are required, a ratio of 3.5. Levy [29] recommends a ratio between 2 and 3, and Downs [30] claims success for a ratio slightly less than 2.

OTHER METHODS OF SUBSTRUCTURING

The above comments were restricted to the component mode synthesis method of substructuring because it seems to be the most highly developed and the most widely used. Alternate methods have been suggested and should be mentioned.

Of course, if one is interested only in global frequencies and mode shapes, an eigenvalue economizer scheme can be applied directly to the global structure to achieve a reasonable condensation of the DOF. The experience of Leung [27] suggests, however, that a combination of condensation and substructuring will be more efficient, and Jennings has pointed out [31] that simultaneous iteration on the complete global structure can be as efficient as condensation when only a few eigenvalues and eigenvectors are desired.

A clear alternative to component mode synthesis is the method of transfer matrices. As Pestel and

Leckie [32] point out in their preface, "Although the transfer-matrix method is suitable for the treatment of branched and coupled systems, its application is unadvisable for systems that lack a predominant chain topology." An example of the application of the transfer-matrix method to a complex system (a cylindrical shell with discrete stringers) is available [33].

Another method, called the method of receptances, was developed by Bishop in a series of papers in the 1950s. Receptance is the same as displacement mobility (the ratio of displacement amplitude to force amplitude), and the method is a member of the family of impedance and mobility methods. It is well suited for predicting the forced response of a system in terms of the receptances of its component parts. The method has been described [34], as has a recent example of its use [35].

In 1964, Gladwell introduced the method of branch mode analysis [36]. The modes of a particular substructure are computed with the assumption that all other connected substructures are rigid. The branch modes are then used in a Rayleigh-Ritz procedure to predict global frequencies and mode shapes. There appear to be few, if any, recent examples of the use of this method.

Finally, Dowell has suggested a method that uses the unconstrained normal modes of the substructures and enforces compatibility among substructures via Lagrangian multipliers [37]. This method has been used to predict global damping from substructure damping [38].

COMMENTS

The concept of substructuring can be manifested in several methods. The component mode synthesis method due to Hurty and Craig and Bampton has proved suitable for machine computation and is the most frequently used. Little work has been done with the other substructuring methods of component mode synthesis: presumably, each method has one or more problem types for which it would be better than or equal to component mode synthesis. Such a comparative study would be arduous but worthwhile. The author would be happy to learn of any such studies for inclusion in any future update of this review.

The author also regards the extension of component mode synthesis to mixed analytical and experimental substructures and to the dynamics of rotating structures as the most interesting recent developments in this methodology. He would appreciate learning of new work along these lines.

Finally, the incorporation of damping into component mode synthesis is a logical and tractable extension of the method. Again, the author would appreciate learning about specific applications of damped substructuring to structural design problems.

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LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains review articles on flow-induced vibration of nuclear reactor fuel; and computer programs: shock and vibration isolation.

Dr. M.W. Wambsganss and Dr. T.M. Mulcahy of Argonne National Laboratory have co-authored a two-part article which focuses on the role of reactor fuel in flow-induced vibrations in nuclear reactors. Part I is on mathematical modeling of the fuel assemblies.

Mr. T.F. Derby of the Barry Wright Corporation has written a review of literature pertaining to computer programs useful in the analysis of shock and vibration isolation. The discussion covers design of isolators, determination of required or optimum isolator parameters, and computational techniques.

FLOW-INDUCED VIBRATION OF NUCLEAR REACTOR FUEL
Part I: Modeling

M.W. Wambsganss and T.M. Mulcahy*

Abstract - This two-part article focuses on the role of reactor fuel in flow-induced vibrations in nuclear reactors. Part I is on mathematical modeling of the fuel assemblies. Part II describes design considerations.

The first of this series of review articles on the subject of flow-induced vibration (FIV) of reactor system components was published in 1976 [1]. That article included reviews of FIV mechanisms; typical reactor systems and their potential for FIV; and state-of-the-art methods employed in design evaluation. In this and subsequent review articles a particular reactor component, or in some cases a class of components, will be featured and reviewed in depth relative to problems experienced, methods available for component design evaluation, and results of specific design evaluation analyses and tests. Reactor components that will be reviewed include fuel, heat exchangers, thermal liners and core barrels, and piping.

This review focuses on the role of reactor fuel in flow-induced vibration. It is appropriate that fuel be considered first because fuel rods were one of the first reactor components to be considered from the standpoint of FIV in the design process [2]. In addition, a significant amount of work has been performed in the development and application of methods for FIV analysis and testing of reactor fuel.

The fuel in power reactors is typically in the form of fuel pellets contained in tubes called cladding. When the pellets are axially loaded by a spring and a gas plenum is provided at the top of the tube, the tubes are called fuel rods or fuel pins. To facilitate handling and to control flow around the cladding, the fuel rods are grouped in bundles. In general, the fuel rods are fixed at one end in a support grid; intermediate support at selected axial locations is provided by additional grids (often consisting of spring clips) or wire wrap. The intermediate supports maintain desired lateral spacing. Control of flow and handling is enhanced if each fuel bundle is placed inside a channel, called a fuel channel box or fuel duct, to form a fuel assembly. Square, hexagonal, and circular channels have been used. Pickman [3], in a review of the interactions between fuel pins and assembly components, and Garzarolli et al [4], in a review of fuel element failures, have discussed fuel element designs of several power reactors. Typical fuel lifetime in the core is three to four years [4].

Fuel rods are typically exposed to reactor coolant at flow velocities up to 10 meters/second (m/s) for a liquid (water and sodium) cooled reactor and up to 108 m/s for gas (helium and carbon dioxide) cooled reactors. The coolant flows nominally parallel to the fuel rods, entering and exiting through inlet and outlet nozzles. All fuel rods vibrate during reactor operation. The primary excitation mechanism, neglecting structural-borne vibrations, is the fluctuating pressure acting on the surface of the rod. Both nearfield and farfield effects are included and -- with the exception of pump pulsations, vortex shedding associated with crossflow components, two-phase periodic slug flow, and narrow-band acoustic resonances -- are broadband and random in nature and result in a narrow-band, random response of the fuel rod.

Fuel rod vibration is a problem only when the amplitude of the vibration is such that material damage or loss of function results. Serious problems result if the cladding is worn through, and the fuel is exposed to the coolant. If fuel rod failure caused by flow-induced vibration leads to flow blockage at the failed location, local overheating can cause the fuel to melt. In general, response amplitudes are

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small; the failure mechanism is wear resulting from rubbing or impact rather than fatigue. Wear occurs at rod/support locations or between the fuel pins and wire wrap spacers.

Reactor designers require methods for predicting the response -- vibration amplitudes and tube/support interaction forces and motions -- of fuel rods to coolant flow excitation and for estimating wear for comparison with allowable wear rates based on design life. However, response prediction is extremely complex for a number of reasons:

- The dynamic behavior of the fuel rod is complicated by nonlinearities resulting from gaps between the fuel rod and wire wrap spacers or from the spring-type spacer grids.
- Fluid/structure interaction results in closely-spaced coupled modes.
- The vibration is force-excited and solution therefore requires mathematical characterization of the forcing function (random wall pressure fluctuations) as well as damping.
- The pumps, piping, and flow channels of different facilities can be expected to produce wall pressure fluctuations unique to each facility.
- Single-phase flow becomes two-phase flow in boiling water reactor fuel assemblies.
- During operation, a fuel rod undergoes both dimensional changes and changes in values of material properties due to irradiation and temperature and pressure variations. Even if response and force predictions are available, design criteria may be difficult to establish because the wear mechanism depends on a variety of parameters related to materials, surface conditions, and environmental properties.

Despite the complexities of response prediction, a basic design framework has been developed. When statistics of the forcing function pressure and the structural dynamic characteristics of rods are known, mathematic models are available for response prediction. However, because pressure statistics are often more difficult to measure than rod response itself, semi-empirical correlations for estimating the response have been formulated for many different types of fuel assemblies. Absolute confidence in the prediction methods and design criteria remain to be established. As a result, prototypic design verification testing is often performed for each new fuel assembly design. The following state-of-the-art review of mathematical models, semi-empirical correlation, and design verification testing is intended to implement acceptable design procedures for nuclear reactor fuel.

MATHEMATICAL MODELING

Solutions for the equations of motion form the basis for the prediction procedure; thus knowledge of fluid forcing-function pressure statistics and structural mass, stiffness, damping, and boundary condition parameters is necessary. The boundary value problem is made tractable by considering idealized representations that can be analyzed. The simplest model -- and the one that has been studied most extensively -- is a single circular rod, supported at its ends and exposed to a fluid flowing nominally in-line with its long axis.

Paidoussis [5] has published an excellent review of the state of the art of mathematically modeling the dynamic behavior of cylindrical structures in axial flow and of predicting subcritical response to fluid flow. His review includes papers published through 1973. The mathematical models are divided into three classes: self-excited [6, 7], forced vibration [8-15], and parametric excitation [16]. It is generally accepted that the forced vibration model is correct. Nevertheless, there may be special cases in which parametric excitation is important, possibly in two-phase flow [17]. More detailed models have been developed to account for fluid/structure coupling that occurs in closely spaced rod bundles [18]. Several additional investigations [19-23] include discussions of modeling and correlations for predicting fuel rod response; the modeling of parallel flow-induced vibration has been discussed by Blevins [24]. Fluid-elastic instability has been studied in some detail by Paidoussis [25-28]; it is not a problem in fuel rod vibration, however, because of the low flow velocities relative to the critical flow velocity associated with instability.

The available information for each term in the equation of motion is reviewed below. In matrix format the general equations of motion for a structure immersed in a fluid flow can be written in terms of structural response $\{q\}$ as

$$[M]\{\ddot{q}\} + [C]\{\dot{q}\} + [K]\{q\} = \{Q\} \quad (1)$$

where $[M] = [M_s + M_f]$

$M_s \equiv$ structural inertia
$M_f \equiv$ added mass of fluid

$[C] = [C_s + C_v + C_f]$

$C_s \equiv$ structural damping
$C_v \equiv$ fluid viscous damping
$C_f \equiv$ flow velocity dependent damping

$[K] = [K_s + K_f]$

$K_s \equiv$ structural stiffness
$K_f \equiv$ fluid-elastic stiffness

$\{Q\} = \{Q_s + Q_w + Q_t + Q_o\}$

$Q_s \equiv$ steady fluid forces
$Q_w \equiv$ wake forces
$Q_t \equiv$ turbulence and buffeting forces
$Q_o \equiv$ other than fluid forces

Self-excited vibrations and instability can be studied with knowledge of only the left side of equation (1); the right side is set equal to zero. On the other hand, prediction of force-excited vibration response requires characterization of the complete equation.

In general, the structural inertia terms of the mass matrix can easily be determined for the small motions prevalent in parallel flow. The contribution of added mass must be accounted for when a structure vibrates in a dense fluid. In such cases, the resulting fluid forces are in phase with the acceleration of the structure and act as added mass; the result is that the natural frequency of the component is less than its value in air. In a fuel rod bundle, the proximity of adjacent elements and boundaries also tends to increase the added mass. Further, because the adjacent rods are flexible, fluid/structure coupling occurs and coupled modes result; with a bundle of k rods there will be 2k coupled modes corresponding to each axial bending mode. A computer program AMASS, based on potential flow theory, has been developed for calculating added mass coefficients [18].

Figure 1 shows the 14 normal modes and frequencies of a seven-rod bundle vibrating in a liquid; the natural

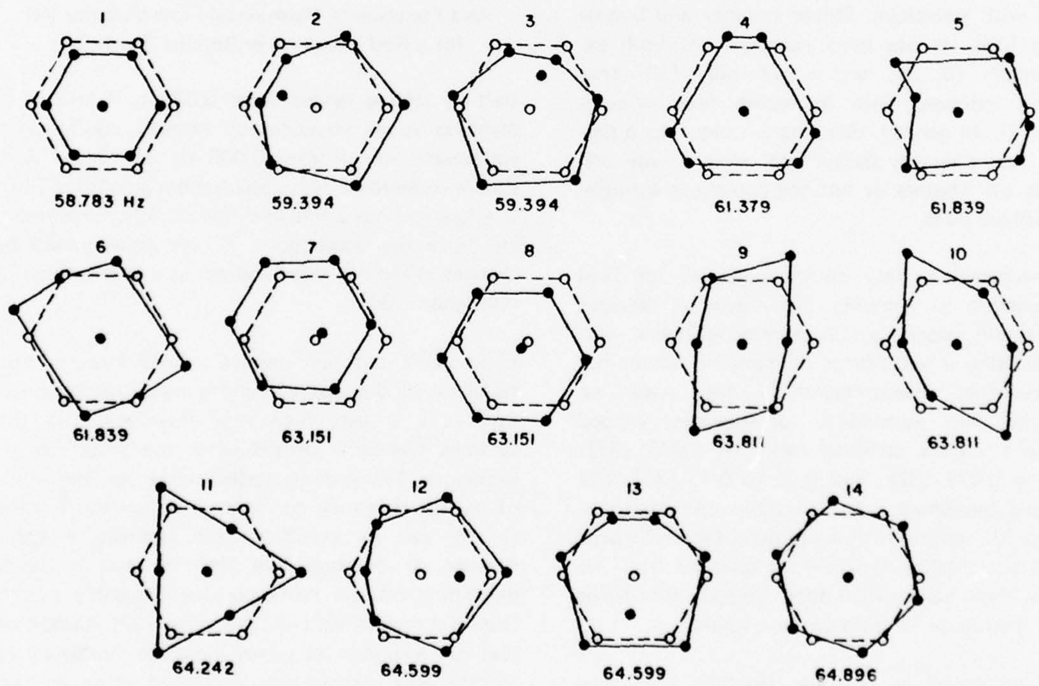

Figure 1. Normal Modes and Frequencies of a Seven-rod Bundle Vibrating in a Liquid [18]

frequency of each identical rod is 65.949 Hz in vacuo and 63.257 Hz in the liquid. As can be determined from Figure 1, fluid/structure coupling tends both to further reduce the lowest natural frequency and to introduce other frequencies. Consequently, it is important that such effects be adequately accounted for in modeling. Very little work has been done toward characterizing added mass for two-phase flow; time and spatial variability of the mass can lead to parametric excitation [17].

Damping is an important consideration in predicting subcritical vibrations. In response to a broadband random load the amplitude will be proportional to the square root of the damping factor. The structural damping includes energy losses due to rubbing and friction at interfaces between the fuel rod and grid spacers (or wire wraps) and at support locations. Vibration of a fuel rod in a dense liquid gives rise to fluid viscous damping; the damping is associated with the viscous drag forces acting on the fuel rod and opposes the lateral velocity of the rod. The viscous damping force is a function of the Stokes number, $\omega d^2/\nu$ (where ω is the vibration frequency, d is the rod diameter, and ν is fluid kinematic viscosity), and bundle spacing. Viscous damping increases with decreasing Stokes number and bundle spacing [29]. It has been demonstrated both experimentally [8, 30] and theoretically [18] that damping increases with increasing flow velocity (Figure 2). In general, damping is unique to a particular fuel assembly design and coolant type and depends on whether or not the coolant is a single- or two-phase fluid.

It is necessary to rely on measurement for final determination of damping, but results of previous measurement programs can provide guidance. Not unexpectedly, a wide range of damping factors has been reported. Measurements in static water on prototypic fuel assemblies, for example, yielded equivalent viscous damping ratios of 0.016 [31], 0.034 to 0.071 [32], and 0.02 to 0.13 [33]. For simulated two-phase flow using air-water mixtures, Gorman [9] reported measured damping coefficients ranging from 0.054 to 0.074 for qualities from 4% to 44%; these values were approximately four times greater than those for a single-phase liquid.

Measurements of guide tube damping from four different reactors during hot functional and/or

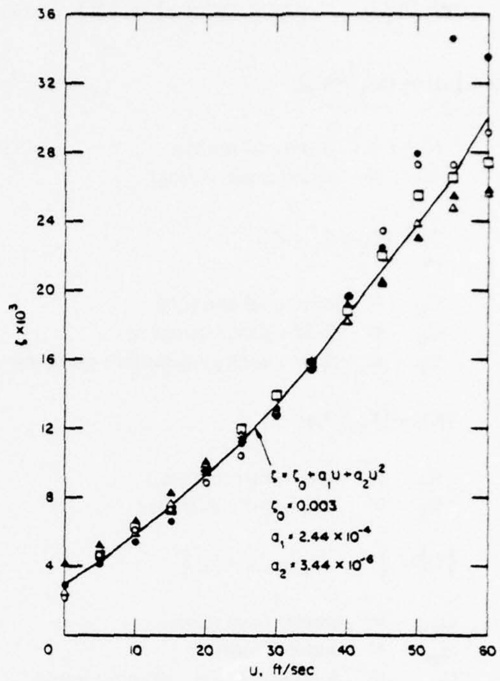

Figure 2. Equivalent Viscous Damping Factor (ζ) as a Function of Mean Axial Flow Velocity (U) for a Rod Vibrating in Annular Flow [14]

start-up testing ranged from 0.036 to 0.060 [34]; damping values measured on primary coolant loop equipment varied from 0.008 to 0.060 and were shown to increase with displacement amplitude [35]. If a fuel rod has a free end, the Coriolis force resulting from the acceleration of the flow caused by changes in the rod slope can act as a strong damping mechanism [36].

Fluid-elastic stiffness implies a fluid force proportional to rod displacement and is important in parallel flow only at very high axial flow velocities; this stiffness can be neglected when the subcritical response of fuel rods is studied. However, the effect of reactor operating conditions on fuel rod flexural rigidity can be significant and can act to either increase or decrease fuel rod response frequency depending on the particular fuel assembly design. During a reactor start-up, Pettigrew [37] found that fuel rod response frequency increased rapidly by up to 50%; the increase was explained as an increase in fuel rigidity due to fuel pellet expansion with

power. On the other hand, a PWR (pressurized water reactor) operating experience indicates a decrease in the lateral response frequency of a fuel assembly due to irradiation effects [38]. Such effects are difficult to account for a priori; additional reactor operating experience is required.

Prediction of subcritical vibration response of reactor fuel rods required characterization of the forcing function; right side of equation (1). Steady fluid forces can be of great importance in cross flow-induced vibration where steady drag forces can be quite large. However, in parallel flow, steady forces are generally negligible. Fluid forces associated with the wake from the component of interest or from upstream components are also important in cross flow. Periodicity in wake flows and the potential for a frequency coincident with the natural frequency of the rod are of most concern. In fuel rod assemblies, support and/or spacer grids are responsible for wake flows that can contribute to fuel rod excitation, primarily by increasing the turbulence level in the flow stream. Vibration forces other than fluid forces, including mechanically induced vibration transmitted through supports, can be significant and, in fact, can dominate the relatively low amplitude subcritical vibrations induced by axial flow. Farfield noise, such as the acoustic waves propagated by pumping pulsations, and fluid column resonances in piping and pressure vessels are usually present and unique to a given facility.

All the excitation mechanisms discussed thus far are highly system dependent and peculiar to each reactor; they are therefore difficult to characterize and discuss in general terms. If rod support motion is available, it can be included in the analysis. If sufficient rod surface pressure measurements can be made in a system, including the turbulent wake producing upstream disturbances and farfield noise, their effects can also be included in the analysis. Because the farfield noise usually has a long wavelength relative to the lengths of the fuel rods and travels as plane waves normal to the rod, its ability to excite the rod is expected to be minimal. However, farfield noise is usually responsible for a large portion of the pressure spectrum in the low (structural) frequency range. Additional reference will be made to these pressures in the following discussion of a primary excitation mechanism amenable to general description.

The boundary layers on fuel rods are turbulent shear flows that induce their own pressure fluctuations on the rod walls. Considerable work has been done on the characterization of wall-pressure fluctuations beneath turbulent boundary layers on flat plates [39-43]; less work has been done on turbulent pipe flow [44, 45] and flow over cylinders [46] and bodies of revolution [47]. The majority of the work has involved wind tunnel testing [39-43, 45, 46]; only a few experiments have been performed in water [44, 47]. Experimental characterization of the pressure field typically involves a series of closely-spaced, miniature pressure transducers, flush mounted on the wall in streamwise and transverse-to-streamwise directions. Spectral analysis and both broadband and narrow-band, space-time correlation techniques are utilized to obtain the frequency distribution of the mean-square pressure and information relating to the convection properties of the pressure field. Farfield noise is pervasive and difficult to remove from a system: few pressure measurements made in quiet wind and water tunnels are recorded below 250 Hz because of spurious noise.

All pressure measurements discussed above were performed in single-phase flow. Much less work has been done for two-phase flow; present characterizations of the pressure field must thus be considered preliminary. Suffice it to say that the pressure field is highly dependent upon the steam to water fraction and may vary from predominantly single phase in character for small fractions to predominantly periodic in character when the phases separate, and slug or annular flow regimes occur. Two-phase flow modeling is not discussed further here; interested readers are referred to a recent review [17].

Solution of random vibration problems requires a model of the cross spectral density. The model proposed by Corcos [48] is widely employed. It assumes separability of power spectral density and longitudinal and lateral correlation decay effects. It has been found suitable for describing pressure fields on surfaces having different curvatures, on smooth and rough surfaces, and on surfaces with both adverse and favorable pressure gradients. Willmarth [49] has reported on the status of pressure fluctuations beneath turbulent boundary layers through 1975. Unfortunately, the majority of the papers referenced focus on the high-frequency behavior of the boundary layer.

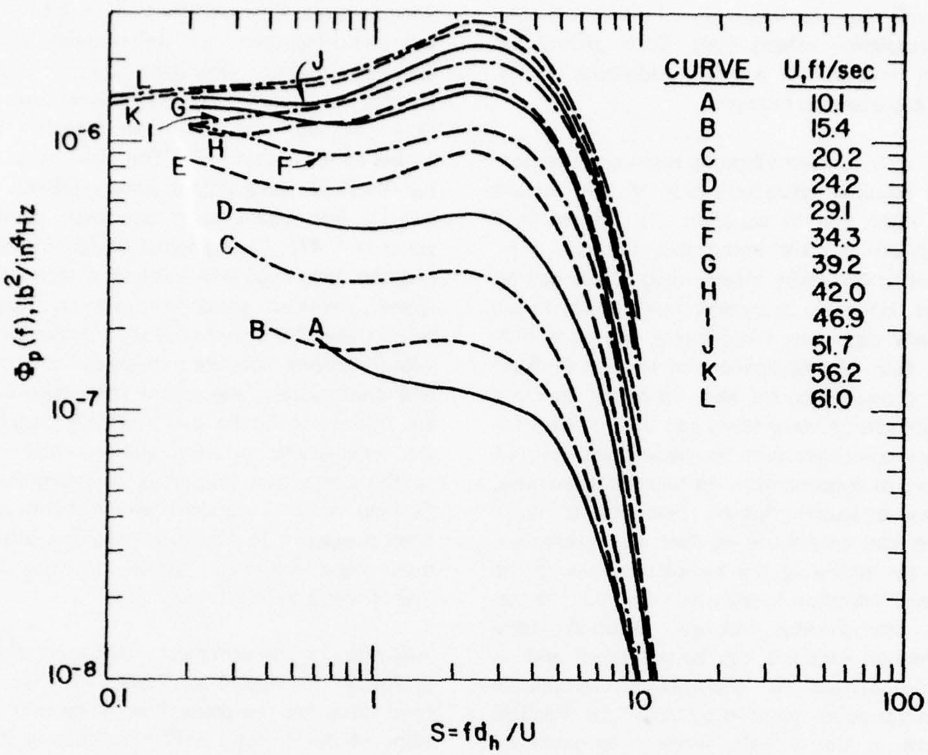

Figure 3. Power Spectral Density of Wall Pressure Fluctuation (Φ_p) as a Function of Reduced Frequency (S) [14, 51]

Fuel rods respond to the low-frequency spectrum of the pressure fluctuations. One of the first studies motivated by the need for pressure information at low frequencies was performed by Wambsganss and Zaleski [50]; a subsequent and more detailed study has recently been reported [51]. It was conceded that farfield noise would be present although a maximum effort was made to remove it; the measuring system used could extract the turbulent boundary layer net pressure component on a single rod located centrally in a pipe. In Figure 3, the power spectral density of the wall pressure fluctuations is plotted for a range of mean axial velocities. Additional investigations, utilizing a similar technique, have been carried out [9, 52-54].

Although few in number, studies of the surface pressure field at low frequencies ω and relatively long wavelength ω/U (where U is mean flow velocity) indicate that the number of independent variables of the pressure field mathematical model [48] must be increased to account for low frequency time and spatial correlation data [17, 41, 44, 51, 55, 56]. The high frequency pressure fluctuations appear to be a function of such inner boundary layer variables as the wall shear stress and the boundary layer displacement thickness δ^*, for $\omega\delta^*/U > 1$. Evidently these pressure fluctuations are present irrespective of the content of the flow outside the inner boundary layer [57]. Pressure fluctuations at decreasingly smaller frequencies and longer wavelengths, $\omega\delta^*/U < 1$,

become functions of such outer boundary layer variables as boundary layer thickness or hydraulic diameter in fully developed pipe flow. It has been speculated [56, 57] that these changes in dependent variables account for the two distinctive regions of the power spectral density (Figure 3): low-frequency relatively large-size turbulent eddies in the outer boundary layer are responsible for the nearly constant part of the spectrum; smaller, higher frequency eddies in the inner layer dominate where the power spectrum decays from a maximum value. Although significant insights are being gained, the problem of measurement and interpretation of the low frequency behavior of the pressure field remains a difficult one, as has been discussed [51].

In the studies above, most pressure measurements were made in spatially homogeneous boundary layers; that is, on the assumption that the statistics describing the pressure field are the same at any location. In application, the presumption of homogeneous pressure fields must be questioned. For instance, spacer grids produce upstream turbulence, and increases in the turbulence levels in the outer boundary layer would be expected. A recent experimental study on a single cylinder [58] was made to study the effects of upstream disturbances and hydraulic diameter on rod vibration. For a small hydraulic diameter-to-rod length ratio of 0.01, the turbulence introduced by upstream disturbances decayed almost immediately and had little effect on rod vibration response; for a three times larger ratio of 0.03, however, rod response increased by a factor of 5. This same trend had been identified earlier [11] in an empirical comparison of the vibration response of similar fuel rods tested at similar flow rates but by different workers in different facilities. For hydraulic diameter-to-length ratios of less than 0.01, all the response results could be collapsed onto a single curve. Above the ratio of 0.01, order of magnitude differences in response occurred and were attributed to differences in pumping facilities and test conditions. The use of empirical correlations is discussed further in the next section.

The proximity of adjacent fuel rods would also be expected to produce nonhomogeneous pressure fields. To date, however, only one study [54] is known in which comprehensive pressure measurements for rod bundles have been made. The results showed that pressure field statistics depend on circumferential position around the rod, as expected. More significant is that multiple structural frequencies were observed that could probably be attributed to the presence of fluid coupled bundle natural frequencies [18]. No attempt was made to solve the coupled fluid-solid boundary value problem, and one-dimensional single rod response predictions methods were made indeterminate because of the nonhomogeneous pressure field and the presence of the multiple rod response frequencies.

Although the pressure field in a tube bundle undoubtedly is nonhomogeneous, due to both spacer grids and proximity of adjacent rods, the assumption of a homogeneous pressure field apparently can be used to predict rod response within an order of magnitude [8, 23, 53, 54]. Considering that most rod responses are on the order of 0.001 mm, such accuracy may be acceptable.

In modeling the structural dynamic behavior of fuel rods, specification of the boundary conditions provided by the support grids and intermediate grid spacers, or wire wraps, becomes a difficult problem. Nonlinearities result if there are gaps between the fuel rod and spacer or if the grid spacers respond as nonlinear springs. Wire wrap spacers, as typically employed in fast reactor fuel bundles, provide for a complex support: a point support is provided that continuously varies around the circumference of the rod. Chelli et al [60] have proposed a code for computing the modes and frequencies of vibration of wire-wrapped fast reactor fuel pins. Fuel rods are often designed with a free end to allow for growth due to differential thermal expansion. In such cases the shape of the free end can have a measurable effect on flow-induced vibration response and should be considered in the design [61].

EMPIRICAL CORRELATIONS

Although numerous difficulties must be overcome in developing a mathematical model, characterization of the forcing function (wall pressure fluctuations) remains the crux of the subcritical forced vibration problem. Because of the difficulty in modeling the forcing function, a number of empirical correlations [2, 10, 11, 15, 16, 19, 62, 63] have been developed that utilize dimensionless analysis, or the form of the equation of motion, and available experimental

results. These correlations have been reviewed by Paidoussis [5] and, more recently, by Henry et al [23], in assessments of the applicability of state-of-the-art information in evaluating GCFR (gas cooled fast reactor) core flow-induced vibrations.

Correlations have been based on test results obtained largely from ambient water flow tests and idealized geometries. Their general application to significantly different fuel assemblies remains open to question and, along with their inability to account for system and operational effects peculiar to a particular plant, comprise the major weaknesses of this method for response prediction. As in the most recent evaluation for GCFR fuel assemblies [23], additional tests are usually proposed to resolve the disparity between the correlation predictions and to assure that a correlation can be extended to include the new application. The reader is referred to the review references given above for details of application.

At best, these correlations can be expected to give order-of-magnitude accuracy. Therefore, in application, they are frequently employed early in the design stage for guidance. However, if the pressure field is known, the theory [8] and design relationship [14] developed by Chen and Wambsganss can be used. Because of uncertainty in the accuracy of the available prediction methods, it is necessary to rely on prototypic testing for final design verification.

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COMPUTER PROGRAMS: SHOCK AND VIBRATION ISOLATION

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Abstract - This article is a review of literature pertaining to computer programs useful in the analysis of shock and vibration isolation. The discussion is broken down as follows: (1) design of isolators; (2) determining required or optimum isolator parameters; (3) computational techniques.

The literature reviewed in this article is primarily that which appeared in "Abstracts from the Current Literature" in the ***Shock and Vibration Digest*** from January 1976 through March 1979.

DESIGN OF ISOLATORS

The finite element program VISCOSUPERB [1] is used to model rubber vibration isolators. The program can be obtained from Structural Dynamics Research Corporation, Cincinnati, Ohio. The static solution incorporates geometric nonlinearities by the piecewise-linear technique by which the geometry is updated at each step. Material nonlinearities are not accommodated in the static solution.

The dynamic solution is the steady-state sinusoidal response to a sinusoidal input force or displacement. This solution is a linear solution at each frequency, but the material properties can be functions of frequency. The initial position for the dynamic solution is taken as the static solution. Comparisons with experimental results show reasonably good agreement.

Actual rubber material properties are dependent upon strain. For situations in which the mount is not strained homogeneously, this dependence on strain cannot be accommodated, and might account for some of the discrepancy.

Another problem associated with the analysis of rubber materials is that Poisson's ratio is approximately equal to 0.5. Unless the elasticity equations have been reformulated (see below), this results in division by zero in the computation. The VISCOSUPERB program cannot handle Poisson's ratio equal to 0.5, and in the examples cited 0.49 is used as the value. This should not cause a problem for those situations in which the bulk modulus does not play a major role; i.e., shear and compression-tension strains when the rubber is not highly confined.

For a linear elasticity problem, the shear modulus and bulk modulus can be written in terms of Young's modulus and Poisson's ratio as follows

$$G = \frac{E}{2(1+\upsilon)}$$

$$B = \frac{E}{3(1-2\upsilon)}$$

where G = shear modulus, B = bulk modulus, E = Young's modulus, and υ = Poisson's ratio. In the tabulation below, the quantities G/E and B/E are shown for Poisson's ratio as it is varied from 0.49 to 0.5. The bulk modulus is very sensitive to small changes of Poisson's ratio in this range, but the shear modulus is not.

υ	G/E	B/E
0.49	0.3356	16.7
0.495	0.3344	33.3
0.499	0.3336	167
0.4995	0.3334	333
0.4999	0.3334	1667
0.5	0.3333	∞

Based on measured values of shear modulus and bulk modulus Poisson's ratio for most rubber materials is between 0.499 and 0.4999. When rubber is highly confined, the solution is very dependent upon Poisson's ratio; it is then necessary to have a precise

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value between 0.499 and 0.4999, as well as a solution technique that can accurately handle such values.

The finite element program TEXGAP [2] can handle Poisson's ratio nearly equal or equal to 0.5 because the equations of elasticity [3] are reformulated. This program gives static elasticity solutions for two-dimensional problems that can be either plane stress, plane strain, or axisymmetric.

A more recent version of the program, TEXGAP3D, can handle three-dimensional problems using a 20-node solid brick element. The original TEXGAP program was written to analyze solid rocket propellant, which, like rubber, has a Poisson's ratio nearly equal to 0.5. The TEXGAP programs are available from Dr. Eric Becker, TICOM, University of Texas.

Modified versions of TEXGAP have been used to analyze elastomeric bearings [4, 5]. These bearings also provide vibration isolation. One of the main design parameters requires the bearings to be very stiff in translation and very soft in rotation. This is achieved by confining the rubber so that it is very stiff in compression but can accommodate rotational motion in shear. The SARLAS program [4] is essentially TEXGAP with the input and output modified for ease of use and interpretation of results. The STABEL program [5] is also TEXGAP with such modifications as a mesh generator for laminated parts and calculation of Von Mises stress for metal parts.

It is fairly common for vibration and shock isolators to undergo large deflections. Large deformations of a nearly incompressible material such as rubber are difficult to analyze. A solution technique that can successfully analyze one such situation may not be able to analyze another so that caution is necessary in interpreting results. Four programs that have the ability to analyze large deformations of nearly incompressible parts include a recent version of TEXGAP, the MARC program [6], the ADINA program [7], and NEPSAP program [7]. MARC, ADIMA, and NEPSAP are general purpose finite element programs and are well documented in the literature.

DETERMINING REQUIRED OR OPTIMUM ISOLATOR PARAMETERS

Three programs, VIBANL, SHKANC and SPECT, were used in the design of a shipping container suspension system for the Harpoon missile [8]. VIBANL computes the steady-state response to sinusoidal inputs. SHKANC computes the transient response to shock inputs, and SPECT computes the shock spectra of acceleration time histories. Descriptions of the input and output are given, but program listings are not.

The ADAMS computer program [9, 10] -- Automatic Dynamic Analysis of Mechanical Systems can be used to determine the isolator spring and damper properties required to effectively isolate complex mechanical systems. The required input to the program is:

- mass, moment of inertia, and location of each part
- type, linkage adjacencies, and location of each joint; joint types are spherical, revolute, universal, cylindrical, translational, and screw
- coefficients and attachment points of springs and dampers
- force and displacement inputs

Capabilities of the program are:

- static analysis
- large displacement (nonlinear) transient analysis
- small displacement (linearized) analysis around a static solution or at any solution point in time, including
  - vibration analysis
  - modal analysis, modal sensitivity, and modal optimization

The method of solution is discussed [9, 10] but the listing is not given.

The DISCOS program [11], Dynamic Interaction Simulation of Controls and Structure, analyzes complex systems composed of many flexible or non-flexible masses connected by linear and nonlinear elements. The program has the ability to analyze large deformations, spinning bodies, and elements with feedback control. The program is

written in FORTRAN for the IBM 360/95 computer system. The derivation of the equations used in the analysis is available, as are flow charts and program listings [11]. This program is useful for the design of active isolation systems.

The program SIMQKE [12] computes simulated acceleration time histories to match a response spectrum or spectral density function. The time history is composed of a series of sine waves with randomly chosen phase angles. In the design of buildings to withstand earthquakes, the importance of earthquake simulation is: use of typical inputs rather than a particular time history measured; simulation of large quakes (e.g., Richter magnitude 8) for which no time histories are available; and use of nonlinear analysis when response spectrum and spectral density are difficult to apply. A user's manual and program listing are given.

The programs APPLE PIE and DESSERT [13] compute structural response due to time history input and random vibration input, respectively. The structure is a multistory shear beam. The programs can be used to determine the effects of an isolation system on such a structure. The programs are described, but the listings are not given.

The VAST computer program [14] is used to determine the effects of mounting gas turbine engine rotors. The bearing mounts can be modeled by nonlinear springs (e.g., stiffness variation and speed) and by different types of damping, including squeeze film damping.

A computer program to obtain steady-state response of an overhung rotor with squeeze film damping devices in conjunction with flexible supports for rolling element bearings is available [15]. The damper is treated as a nonlinear device. A brief flowchart is given, but the listing is not. The input data are:

- mass, flexibility, and damping submatrices of rotor and stator
- the speed range of interest, increment step, and critical values of speed
- assigned eccentricities of rotor masses and their phases (of which many combinations may be given)
- various values of retainer spring stiffness to be tested
- damper diameter and various values of ratio, clearance ratio, and damping oil viscosity that may be tried.

The program DASS [16], Design of Active Suspension Systems, is used to design either feedback or feedforward active suspension systems for railroad cars. It is used primarily for those high-speed trains in which it is cheaper to use active suspension systems than to upgrade the track.

The program TRAVSIM [17], TRAcked Vehicle SIMulation, models air cushion and auxiliary suspension systems for a railroad car traversing a guideway with flexibility and irregularities. Model equations are given, but a user guide and listing are not.

A set of computer programs used for analysis of rail vehicle dynamics has been described [18]. The modeling capabilities of the programs FULL, FLEX, LATERAL, and HALF are given, as are the listing and input format. The model for the program FULL is a single rail vehicle consisting of a rigid car body and two trucks. The dynamic input is vertical sinusoidal rail irregularity. Wheel/rail forces and track compliance are not considered. The primary suspension system supporting the truck consists of linear springs. The secondary suspension system, between the truck and car body, consists of a linear spring and viscous damper in parallel. The FLEX program is the same as FULL but includes the first bending mode of the car body. The LATERAL program is similar to FULL but has lateral as well as vertical motions, inputs, and suspension systems. The HALF program models half a rigid car body and one truck. Wheel/rail forces and track flexibility are included.

The program DYNALIST II models railcars on suspension systems traversing irregular track. Vertical and lateral motions are accounted for. The model and equations used are described [19a], and a user's manual gives the flowchart of the program, input data description, description of the output, and sample problems [19b].

A computer program for modeling a railroad freight car has been described. Track irregularities, car flexibility, and suspension system are included in the model. Twenty simultaneous, nonlinear, second order differential equations are solved by the Runge-Kutta technique. Graphical results obtained from the

program are presented, but the program listing is not given.

A computer program used to analyze the effects of an impact caused by one rail car striking others already coupled is available [21]. The effect of the coupler design in reducing the shock due to impact is discussed. In extreme cases the vertical motion can be great enough to disengage couplers, thereby causing damage. The program listing is not given.

Another computer program analyzes truck suspension of rail cars [22]. The nonlinear effects of snubbers and Coulomb friction are taken into account. The car body is modeled as a linear flexible structure by normal modes. Wheel/rail separation is included in the model. The program listing is not given.

A computer program is available to analyze a road vehicle double wishbone front suspension [23]. The model includes the effects of tire stiffness, lower arm bushing compliance, compliance of ball joint connections of the tie rod to the steering knuckle and vehicle body. Changes in geometry due to deflections are taken into account. The suspension spring and shock absorber are modeled as a massless spring and dashpot, respectively. Properties of the spring and dashpot may be considered either linear or nonlinear. Results are in good agreement with experimental results. A brief flowchart is presented and input data to the program are defined, but the program listing is not given.

A computer program has been developed to analyze the shock response of a truck due to an airdrop [24]. The model includes the engine, transmission, front and rear differentials, transfer case, and wheels as lumped masses. The remaining masses of the truck and load are uniformally distributed along the frame. Beams are used to model the frame. Shock mounts connect the engine to the frame, and leaf springs connect the wheels to the frame. The truck is cushioned for impact with paper honeycomb; the force due to impact is modeled as a square wave. Structural damping is included by assuming that the damping matrix is proportional to the mass and/or stiffness matrix. The Runge-Kutta method is used to solve the equations. Comparison of computer results to experimental results is given, but the program listing is not.

COMPUTATIONAL TECHNIQUES

A method that can be used to determine optimum isolation parameters has been described [25]. The optimizing procedure is done in two steps; in the first the isolators are replaced by control forces. The limiting performance of this system gives the control forces. In the second step isolator parameters that best fit the limiting performance control forces are determined. For the commonly encountered case in which the isolators are nonlinear devices and the structure to be isolated can be represented by a linear model, this procedure is more efficient than conventional methods because the entire structural system need not be analyzed for every change of isolator parameters. This method was applied to suspension systems for rotating shafts [26]. A procedure [27], using this method for designing optimum vibration isolators, uses a general purpose finite element computer program to model the structure to be isolated.

Advantages and disadvantages of various methods for incorporating damping in large general purpose computer programs have been discussed [28]. Damping in most structures is very small, but damping in vibration isolators is significant. In the latter it is important to have an accurate but computationally simple method for incorporating damping into large general purpose computer programs.

The modeling of Coulomb friction dampers used in freight car suspensions has been discussed [29]. Results of this study indicate that the slider model is more accurate than the linear viscous band model. Program listings for both models are given.

A frequently encountered problem is overheating of vibration isolators due to the internal heat generated while they are subjected to sustained vibrations. A method for solving dynamic coupled thermoviscoelastic problems undergoing sustained periodic motions is applicable to geometrically complex structures [30]. The method can utilize existing elastic computer codes, with modifications, to obtain the viscoelastic results.

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BOOK REVIEWS

SHOCK TUBE AND SHOCK WAVE RESEARCH: PROCEEDINGS OF THE ELEVENTH INTERNATIONAL SYMPOSIUM

B. Ahlborn, A. Hertzberg, and D. Russell, Editors
Univ. of Washington Press, Seattle

This volume contains 74 papers. The subject areas of the various sessions are shock propagation and structure, molecular rate processes and spectroscopy, shock structure and application, chemical reaction, Mach reflection and boundary layers, shock particle interactions, and diagnostics. There are an impressive series of invited papers on topics ranging from the interaction of weak shock waves with turbulent media, to the creation of molecules in nonequilibrium situations, to the generation of coherent radiation and new classes of fusion machines. These diverse topics have a common bond; that is, the ability of the shock tube or shock waves to provide the conditions needed to investigate these phenomena.

The papers clearly reflect areas of current interest to the research community. Some of the papers are on completed work; others are on work in progress. As such, this volume is an excellent review of the current state of the art.

This symposium proceedings should be of interest to a wide range of specialists; e.g., engineers, laser researchers, spectroscopists, aerodynamicists, and plasma physicists. In addition, the review papers, with their extensive lists of references, should be of special interest to graduate students.

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ON THE INTERACTION BETWEEN SELF-EXCITATION AND PARAMETRIC VIBRATIONS

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SNTL-Publishers of Technical Literature in the Centre of International Publications
Prague, Czechoslovakia, 1978

This monograph is a new addition to the theory of parametric vibration when a source of self-excitation exists. It is a direct sequel to Professor Tondl's previous work, which was devoted to an analysis of the interaction between self-excited and forced vibrations. The new monograph considers systems whose motion is described by a combination of the Van der Pol and Mathieu equations.

The monograph is a self-contained reference with seven chapters. The first chapter is a general introduction. The methods of analytic solutions for single- and two-degree-of-freedom systems are described in the second chapter. Analytical and analog solutions of systems described by the combined Mathieu-Van der Pol equation are given in the third chapter. For this class of systems Professor Tondl concludes that the frequency of the component of self-excited vibration is constant, independent of the frequency of parametric excitation, regardless of the value of the amplitude of the component of parametric vibration.

Dry friction represented by Coulomb's friction is introduced in the fourth chapter. Neither self-excited nor parametric vibration can be initiated without the application of an initial deflection or impulse. The larger component is the component of positive dry friction; the smaller component is the domain of attraction of the equilibrium position. After exceeding a certain value, the component of self-excited vibration can be suppressed so that only parametric

vibrations occur within the frequency range of parametric excitation. Analog solutions are extensively illustrated in the neighborhood of parametric resonance.

Chapter five contains the analysis of systems; restoring force is expressed as the product of a periodically variable coefficient and a nonlinear stiffness function. In addition to the well-known parametric resonance -- which corresponds to the intervals of instability of the trivial solution of the Mathieu equation -- other types of resonances can also occur. No correlation with other similar studies is given, including those conducted by Tso and Caughey "Parametric Excitation of a Nonlinear System" (J. Appl. Mech., Trans. ASME, 32, pp 899-902) and by Schmidt and Heinrich "Nonlinear Parametric Resonance" (Z. angew Math. Mech., 52, pp 167-171).

The study is extended in the sixth chapter to systems with two degrees of freedom. There exists not only the possibility that parametric resonance of the second kind will be initiated but also that several steady states of self-excited vibration will occur outside the range of parametric resonance. Low frequency vibrations can arise as a result of the linear combination of the natural frequencies of the system and the excitation frequency. The low-frequency component could be physically explainable as the interaction between self-excitation and external or parametric excitation.

The important results are summarized in chapter seven. The book contains three appendices and a list of 13 references.

This monograph is indeed a valuable contribution to the problem that is rarely treated in the literature. It will be of great interest to those working in the field of parametric and self-excited vibrations.

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Heliopolis, Cairo, Egypt

FAILURE DATA AND FAILURE ANALYSIS: IN POWER AND PROCESSING INDUSTRIES

ASME Publication PVP-PB-023
Presented at the Energy Technology Conference
Houston, Texas, 1977

This small volume consists of nine papers dealing with failure analysis and failure prevention. Prevention of failure implies good economics. The loss of revenue caused by shutdown of a nuclear power plant or petrochemical plant amounts to thousands of dollars per day and indirectly costs the consumer money. Information about the causes of failure, as well as past successes, adds to the knowledge available for preventing or minimizing future failures. In recent years, failure analysis has become an integral part of engineering studies and has increased the profits of large installations, ultimately resulting in lower capital costs for future nuclear power plants and petrochemical plants.

The first two papers consider data collection systems currently in operation in the United States and the Federal Republic of Germany. The authors discuss recent changes that make these systems more responsive to the push for power plant availability. The German government uses the collected data extensively for failure prevention at nuclear power plants.

The third paper discusses failure analysis and failure data collections in the ERDA coal conversion system and describes how the system is utilized to assure reliability in future power plants. The main causes of equipment failure stem from sulfidation and erosion.

The fourth paper is a review of piping reliability in light water reactors. Failures at nuclear facilities are attributable either to intergranular stress corrosion cracking or operational errors. This paper is worth the attention of piping engineers, power plant designers, and power plant operators.

The fifth paper considers failure data in processing industries. The author stresses the use of order-of-magnitude data adapted from the literature and supplemented with locally observed system- and environmentally-dependent values.

The sixth paper considers failure analysis and important risk analysis and their roles and proper relationships in comprehensive data evaluation programs. The fault tree concept is introduced. Essentially, it is a deductive logical model in which "and gates" and "or gates" are employed to break down general results or events into basic aspects.

The seventh paper presents a workable approach to extending the life of expensive life-limited components. The approach involves inspection and use of fracture mechanics-based fatigue analysis to calculate the stress that causes a crack to grow to a measured depth. A life-based safety factor is used to obtain an allowable life extension when the component is returned to service. The example is the application of a disc on a rotor. The authors label this as a retirement for cause (RFC) procedure in which turbine rotors and other life-limited components are retired from service because of measurable fatigue or wear damage rather than because a calculated design life has expired.

The eighth paper discusses in detail the generation of fault tree analysis as a safety approach for identification and evaluation of hazards in systems.

The last paper describes the GO procedure, which utilizes a set of standardized operators or components to describe the logical operation, interaction, and combination of physical equipment. The standardized set of operators are identified by their type numbers of GO building blocks. The signals can be electrical, mechanical, or hydraulic. This procedure is a good application of computer programs to failure prevention analysis; it allows the investigator to concentrate on the most important aspects of the system.

In summary, the book does furnish the analyst and designer with a good introduction to the most up-to-date methods employed in reliability analysis. It will be useful as a stepping stone to more advanced aspects of failure analysis and reliability.

H. Saunders
General Electric Company
Building 41, Room 319
Schenectady, New York 12345

DESIGN OF MACHINE ELEMENTS
Fifth Edition

M.F. Spotts
Prentice Hall, Inc., Englewood Cliffs, NJ, 1978

This book is the fifth edition of a standard in its field. The most significant change from previous editions is the introduction of S.I. units, which are used in parallel with English units. As stated by the author, the object of the book (sic) is to present, at a professional level, a comprehensive survey of analytical design methods which can be applied in the broad and ever-widening field of mechanical equipment.

The work is presented in 14 chapters, titled as follows: Fundamental principles; Working stresses; Shafting; Springs; Screws; Belts, clutches, brakes & chains; Welded & riveted connections; Lubrication; Ball and roller bearings; Spur gears; Bevel, worm and helical gears; Miscellaneous machine elements; Dimensioning and details; and Engineering materials.

The chapter on fundamental principles is particularly valuable to the educator in the machine design field. It contains reviews of the basics of statics and strength of materials courses and should serve to convince students that design is the application of principles learned in previous course work. In the remaining chapters, without exception, the material covered is the conventional design information found in competing books. However, all chapters are comprehensive, so that an even level of coverage is achieved; the book is an excellent reference and will thus be of great value to practicing engineers. Particularly helpful is the list of references at the end of each chapter.

The book is also highly desirable as a college text. The material is readable; derivation of formulas is utilized only to help the reader recognize the assumptions and limitations of the design equations. The text contains worked examples. Additional problems for student assignment are included in each chapter,

and the solutions manual (available from the publisher) is complete. The only major omission in the book is the integration of digital computing methods into design. Such a chapter could be included to indicate the types of programs available to designers, especially in kinematics, dynamics and vibrations, and stress analysis.

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SHORT COURSES

NOVEMBER

VIBRATION DAMPING

Dates: November 5-8, 1979
Place: University of Dayton Research Institute
Objective: Topics to be covered are: damping behavior of materials, response measurements of damped systems, surface damping treatments on vibrating members, discrete damping devices, special analytical problems, increasing linear viscoelastic material properties, damping of acoustic vibrations, selected case histories, problem solving sessions, and demonstration of digital fast fourier analyses.

Contact: Mrs. Audrey G. Sachs, University of Dayton Research Institute, Dayton, OH 45469 - (513) 229-2919.

DYNAMIC ANALYSIS WORKSHOP

Dates: November 5-9, 1979
Place: San Diego, California
Objective: This course will cover the latest techniques of analyzing noise and vibration in rotating machinery and power-driven structures. The workshop will cover both the theory and practical aspects of tracking down malfunctions and preventing failures caused by unbalance, misalignment, wear, oil whirl, etc. Included in the course will be demonstrations and practical, hands-on experience with the latest noise and vibration instrumentation; Real Time Analyzers, FFT Processors, Transfer Function Analyzers and Computer-Controlled Modal Analysis Systems. Actual case histories and specific machinery signatures will be discussed.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 565-8211.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: November 5-9, 1979
Place: Arlington, Virginia
Dates: December 10-14, 1979
Place: Ling Electronics, Anaheim, California
Dates: February 4-8, 1980
Place: Santa Barbara, California
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis, also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

THE APPLICATION OF VIBRATION MEASUREMENT AND ANALYSIS IN MACHINE MAINTENANCE

Dates: November 6-8, 1979
Place: New York, New York
Dates: November 13-15, 1979
Place: Dallas, Texas
Objective: These sessions are designed to give an understanding of the concept of using machinery vibration as a means of detecting wear in rotating parts, and of predicting machinery breakdowns. It will deal with the principles and methods of machine condition analysis and the economic benefits obtainable from condition monitoring. Fundamentals of vibration measurement and analysis are explained with particular reference to optimum choice of measurement parameters and techniques to avoid unneccessary errors and limitations in detection and diagnostic capability.

Contact: B&K Instruments, Inc., Bruel & Kjaer Precision Instruments, 5111 W. 164th St., Cleveland, OH 44142.

CONTROLLING THE EFFECTS OF PULSATIONS AND FLUID TRANSIENTS IN PIPING SYSTEMS

Dates: November 7-9, 1979

Place: San Antonio, Texas

Objective: The seminar will cover various means for preventing and controlling the detrimental effects of pulsations and fluid transients on piping, pumps, compressors, and other plant systems and equipment. Topics will include: pulsation generation mechanisms and their effects in plant piping and equipment; the SGA Compressor Installation Simulator (SGA Analog) and its applications; pulsation control and piping system design; mechanical response of plant components to pulsations and transient excitation; vibration control in piping systems; vibration-induced stress and meaningful stress criteria; transient fluid interaction of system components (flow instabilities, cavitation, flashing, piping effects on surge, etc.); effects and control of pulsations in flow measurement; and pulsation effects on the performance of compressor/pump installations.

Contact: Joe L. Gulinson, Southwest Research Institute, P.O. Drawer 28510, San Antonio, TX 78284 - (512) 684-5111, Ext. 2521.

THE 17TH ANNUAL RELIABILITY ENGINEERING AND MANAGEMENT INSTITUTE

Dates: November 12-16, 1979

Place: The University of Arizona

Objective: The following subjects will be covered: reliability engineering theory and practice, mechanical reliability prediction, reliability testing and demonstration, maintainability engineering, product liability, and reliability and maintainability management.

Contact: Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering Department, Aeronautical Engineering Building No. 16, University of Arizona, Tucson, AZ 85721 - (602) 626-2495/626-3901/626-3054.

SURFACE BLASTING

Dates: November 14-16, 1979

Place: Tucson, Arizona

Dates: December 5-7, 1979

Place: Washington, D.C.

Objective: This is a field-oriented course on commercial surface blasting (quarries, open pits and construction). The course uses a variety of presentation techniques including movies, problem solving, question and answer sessions and special "hands-on" exercises. Topics to be covered are: commercial explosives in use today; detonation methods; rock breakage; blast design; blasting economics; and blasting and the neighbors.

Contact: E.I. du Pont de Nemours & Co. (Inc.), Applied Technology Division, Room 35901, Wilmington, DE 19898 - (302) 774-6406.

DECEMBER

MACHINERY VIBRATION ANALYSIS

Dates: December 11-13, 1979

Place: New Orleans, Louisiana

Objective: The topics to be covered during this course are: fundamentals of vibration; transducer concepts; machine protection systems; analyzing vibration to predict failures; balancing; alignment; case histories; improving your analysis capability; managing vibration data by computer; and dynamic analysis.

Contact: Bob Kiefer, Spectral Dynamics, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

JANUARY

PROBABILISTIC AND STATISTICAL METHODS IN MECHANICAL AND STRUCTURAL DESIGN

Dates: Janaury 7-11, 1980

Place: Tucson, Arizona

Objective: To provide practical information on engineering applications of probabilistic and statistical methods, and design under random vibration environments. Modern methods of structural and mechanical reliability analysis will be presented. Special emphasis will be given to fatigue and fracture reliability.

Contact: Dr. Paul H. Wirsching, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-3159/626-3054.

FINITE ELEMENT ANALYSIS

Dates: January 7-11, 1980

Place: Tucson, Arizona

Objective: The purpose of this course is to provide structural engineering practitioners with an understanding of the fundamental principles of finite element analysis, to describe applications of the method, and to present guidelines for the proper use of the method and interpretation of the results obtained through it. Emphasis will be placed upon the linear analysis of frameworks, plates, shells and solids; and dynamic analysis will also be treated.

Contact: Dr. Hussein Kamel, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-1650/626-3054.

FEBRUARY

FIXTURE DESIGN FOR VIBRATION AND SHOCK TESTING

Dates: February 11-15, 1980

Place: Santa Barbara, California

Dates: March 10-14, 1980

Place: St. Petersburg, Florida

Objective: The relative merits of various types of shakers and shock test machines are briefly considered, with most emphasis on electromagnetic shakers. The seminar will be devoted to practical and proven simplified design and fabrication techniques. An important area to be covered is that of evaluating a fixture once it is built.

Contact: Wayne Tustin, Tustin Institute of Technology, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

FINITE ELEMENTS IN BIOMECHANICS

Dates: February 18-21, 1980

Place: Tucson, Arizona

Objective: As a forum for the exchange of ideas, for the definition of the state-of-the-art, and for the presentation of new research results in biomechanics.

Contact: Professor Bruce R. Simon, Dept. of Aerospace and Mechanical Engineering, College of Engineering, The University of Arizona, Tucson, AZ 85721 - (602) 626-3752/626-3054.

BALANCING OF ROTATING MACHINERY

Dates: February 26-28, 1980

Place: Shamrock Hilton, Houston, Texas

Objective: The seminar will emphasize the practical aspects of balancing in the shop and in the field. The instrumentation, techniques, and equipment pertinent to balancing will be elaborated with case histories. Demonstrations of techniques with appropriate instrumentation and equipment are scheduled. Specific topics include: basic balancing techniques (one- and two-plane), field balancing, balancing without phase measurement, balancing machines, use of programmable calculators, balancing sensitivity, flexible rotor balancing, and effect of residual shaft bow on unbalance.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

MARCH

MEASUREMENT SYSTEMS ENGINEERING

Dates: March 10-14, 1980

Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS

Dates: March 17-21, 1980

Place: Phoenix, Arizona

Objective: Program emphasis is on how to increase productivity, cost-effectiveness and data-validity of data acquisition groups in the field and in the laboratory. Emphasis is also on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

MACHINERY VIBRATIONS COURSE

Dates: March 17-20, 1980

Place: Oakbrook Hyatt House, Oakbrook, IL

Objective: This course on machinery vibrations will cover physical/mathematical descriptions, calculations, modeling, measuring, and analysis. Machinery vibrations control techniques, balancing, isolation, and damping, will be discussed. Techniques for machine fault diagnosis and correction will be reviewed along with examples and case histories. Torsional vibration measurement and calculation will be covered.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

VDI Vibration Conference

The Design and Development Section of the Society of German Engineers (VDI-Gesellschaft Konstruktion u. Entwicklung) is holding the next VDI-Vibration Conference October 2-3, 1980 in Düsseldorf. This conference will deal with vibration-induced damage, rotor dynamics, vibration of reciprocating engines, and structural dynamics.

The session on vibration-induced damage will consist of the following topics: fault diagnosis, machinery monitoring, fault analysis, and damage prevention. In the rotor dynamics session papers on vibration of blades, shafts and foundations, as well as balancing and stability investigations and resonance run-through, are solicited. In the vibration of reciprocating machinery, problems of coupling with drive and operating machinery, crankshaft vibrations and problems of vibration emission, vibration isolation and vibration control, are to be discussed. The papers should have a clear application as well as a methodical approach. In the interest of the audience, which will consist mainly of application engineers, clear and simple presentations are preferred. Mathematical details should be kept to a minimum.

Those interested in presenting a paper should submit their topics by December 30, 1979 to Prof. Dr.-Ing. W. Stühler, TU Berlin, 1 Institut für Mechanik, Einsteinufer 5-7, 1000 Berlin 10. A short abstract of the paper, which should not exceed two pages should include the following: 1) topic, 2) author, 3) coauthor, 4) presentation of the problem, 5) methods of investigation, 6) results, 7) application and transferability of results.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALYTICAL METHODS

79-1888

Dynamic Analysis and Design Sensitivity Analysis of Mechanisms with Intermittent Motion

P.E. Ehle

Ph.D. Thesis, The Univ. of Iowa, 246 pp (1978) UM 7912848

Key Words: Mechanisms, Intermittent motion

In this thesis, a new method that can serve as the basis for a general computer code is developed. This approach, called the logical function method, is rooted in an area of mathematics called the theory of distributions.

79-1889

Response Analysis of a Vibrational System of Multi Degrees of Freedom Subjected to an Arbitrary Force

K. Ishihara and M. Funakawa

The Technical Lab., Kawasaki Heavy Industries, Akashi, Japan, Bull. JSME, 22 (167), pp 648-654 (May 1979) 13 figs, 5 refs

Key Words: Multidegree of freedom system, Vibration response

The response of a vibrational system of multi degrees of freedom is analyzed, applying Cayley-Hamilton's theorem. The results calculated by the method proposed in the present report are compared with the experimental ones.

79-1890

Steady Impact Vibration of a Body Having Hysteresis Collision Characteristics (4th Report. Method of Approximate Solutions and Comparison with Exact Solutions)

T. Watanabe, H. Shibata, and S. Maezawa

Faculty of Education, Yamanashi Univ., Takeda 4-4-37, Kofu, Japan, Bull. JSME, 22 (167), pp 655-660 (May 1979) 10 figs, 4 refs

Key Words: Impact response (mechanical), Impact pairs

Analysis of steady impact vibrations taking into account both the elastic and plastic behaviors of colliding bodies is undertaken by approximate solutions. Hysteresis loop characteristics for restitutional force of the system are assumed to be composed of three straight-line segments. The resonance curves and the impact duration time curves are obtained for the amplitude versus the frequency ratios with respect to several fixed exciting forces and the non-dimensional duration time in one period of its vibration versus the frequency ratios with respect to characteristics for restitutional force, respectively.

79-1891

The Technique of Correlation, Selection of Correlation Parameters and Applications to Noise and Vibration Analysis

V. Marples and A. Ryde-Weller

Dept. of Engrg., Univ. of Warwick, Coventry CV4 7AL, UK, Appl. Acoust., 12 (2), pp 93-109 (Mar 1979) 6 figs, 1 table, 3 refs

Key Words: Correlation technique, Acoustic data, Vibration analyzers, Sound analyzers

Following an analysis of the limitations imposed on the mathematical technique of correlation by its practical implementation, the applicability of correlation with acoustic noise and mechanical vibration signals is analyzed in terms of frequency bandwidth and length of record.

79-1892

Non-Linear Boundary and Eigenvalue Problems for the Emden-Fowler Equations by Group Methods

W.F. Ames and E. Adams

Center for Appl. Mathematics, Univ. of Georgia, Athens, GA 30602, Intl. J. Nonlin. Mech., 14 (1), pp 35-42 (1979) 1 table, 21 refs

Key Words: Boundary value problems, Eigenvalue problems

Two pragmatic boundary value and eigenvalue problems of the Emden-Fowler equation are studied using the simple one parameter group properties. In all cases boundary value problems are converted into initial value problems using

the property of the invariance group. An eigenvalue problem is detailed and calculations presented.

79-1893

On the Existence and Bifurcation of Minimal Normal Modes

T.L. Johnson and R.H. Rand

Gas Turbine Div., General Electric Co., Schenectady, NY 12345, Intl. J. Nonlin. Mech., 14 (1), pp 1-12 (1979) 13 figs, 15 refs

Key Words: Normal modes

Minimal normal modes (MNMs) are defined as nonlinear normal modes which give a true minimum to Jacobi's Principle of Least Action. The nature of both generic and nongeneric bifurcations of MNMs is derived and illustrative examples are given.

79-1894

An Integral Equation for Dynamic Elastic Response of an Isolated 3-D Crack

B. Budiansky and J.R. Rice

Div. of Appl. Sciences, Harvard Univ., Cambridge, MA, Wave Motion, 1 (3), pp 187-192 (July 1979) 6 refs

Key Words: Cracked media, Periodic excitation, Dynamic response

By use of a steady state dynamic elastic representation theorem for fields created by relative motions on the faces of a crack, the problem of steady state response of an isolated three-dimensional planar crack loaded by tractions on its surfaces is reduced to an integral equation.

OPTIMIZATION TECHNIQUES

79-1895

Mechanism and Structural Design Via Optimality Criterion Techniques

M.R. Khan

Ph.D. Thesis, Clarkson College of Tech., 181 pp (1979)

UM 7906078

Key Words: Optimization, Finite element technique, Design techniques, Vibration response

The purpose of this research is to develop widely applicable optimization techniques to the design of large scale structures and complex high speed planar mechanisms under vibrational effects. The optimization techniques presented are based on optimality criterion methods. The structural analysis is performed using a standard finite element method. The mechanism analysis is done using the constant length finite element technique. Also a modified finite element technique is developed to analyze mechanisms having variable cross-sectional size links.

79-1896

Dynamics of Structural Systems and Power Units (*Zur Dynamik des Systems Bauwerk und Maschinensatz*)

H. Pircher and Th. Schwirzer

Schwingungen von Maschinen und Bauwerken. Modellfindung. Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978. VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 9-14, 7 figs (In German)

Key Words: Hydroelectric power plants, Optimization, Natural frequencies, Design techniques

Analytical and experimental techniques for the design of water power houses are described. They include system determination, modeling, and the determination of characteristic values.

STABILITY ANALYSIS

(Also see No. 2102)

79-1897

Parametrically Excited Nonlinear Multi-Degree-of-Freedom Systems

E.G. Tezak

Army Military Personnel Ctr., Alexandria, VA, 168 pp (Mar 1979)

AD-A065 175/2GA

Key Words: Harmonic excitation, Parametric excitation, Multidegree of freedom systems, Modal damping

An analysis of parametrically excited nonlinear multi-degree-of-freedom systems is presented. The nonlinearity considered is cubic and small so that the system of equations is weakly nonlinear. Modal damping is included and the parametric excitation is harmonic. The systems examined include those with distinct natural frequencies as well as those with a single repeated frequency. The significant role played by the existence of an internal resonance is explored in depth.

79-1898

Stability Analysis of Systems with Periodic Coefficients: An Approximate Approach

S.C. Sinha, C.C. Chou, and H.H. Denman
Dept. of Mech. Engrg., Kansas State Univ., Manhattan, KS 66506, J. Sound Vib., 64 (4), pp 515-527 (June 22, 1979) 1 fig, 13 refs

Key Words: Stability analysis, Periodic functions

The paper deals with an approximate method of stability analysis for second order linear systems with periodic coefficients. The periodic functions are approximated during the first period of motion by a constant, a linear or a quadratic function of time such that the resulting approximate equations have known closed form solutions. The approximate equivalent equations are generated through an expansion of periodic coefficients into ultraspherical polynomials. The stability criteria is determined from the solution of approximate equivalent system and the generalized Floquet theory.

79-1899

A Simplified Stability Criterion for Nonconservative Systems

I. Fawzy
Dept. of Mech. Design, Faculty of Engrg., Cairo Univ., Cairo, Egypt, J. Appl. Mech., Trans. ASME, 46 (2), pp 423-426 (June 1979) 16 refs

Key Words: Dynamic stability, Lyapunov's method

Dynamic stability of a general nonconservative system of n degrees of freedom is investigated. A sufficient and necessary condition for the stability of such a system is developed. It represents a simplified criterion based on the famous Lyapunov's theorem.

79-1900

On the Stability of Steady Motions in Free and Restrained Dynamical Systems

P. Hagedorn
Technische Hochschule Darmstadt, Germany, J. Appl. Mech., Trans. ASME, 46 (2), pp 427-432 (June 1979) 1 fig, 19 refs

Key Words: Dynamic stability

In this paper the stability of the steady motions of dynamical systems with ignorable coordinates is considered. In addition to the original free systems, restrained systems are defined. The relation between the stability behavior of these two types of systems is examined in detail and several stability and instability theorems are given for damped and undamped systems. An illustrative example deals with the steady motions of a heavy gyrostat.

79-1901

On the Stability of Periodically Time Varying Systems

D.R. Corrall
School of Engrg. and Science, Polytechnic of Central London, UK, Intl. J. Control, 29 (3), pp 497-504 (Mar 1979) 9 refs

Key Words: Stability, Linear systems, Time-dependent parameters

Analytical methods for the stability determination of a linear periodically time varying system are presented in terms of its impulse response and two derived parametric transfer functions. The relationship of these functions, and the relationship between the function poles and the system characteristic multipliers is established.

STATISTICAL METHODS

79-1902

The Method of Maximum Likelihood Applied to the Statistical Analysis of Fatigue Data

J.E. Spindel and E. Haibach
British Railways, London, UK, Intl. J. Fatigue, 1 (2), pp 81-88 (Apr 1979) 9 figs, 12 refs

Key Words: Fatigue tests, Statistical analysis, Computer programs

The application of the principle of maximum likelihood to the analysis of fatigue test results, including run-outs, is

described. The paper describes the use of this method in determining means and standard deviations for test results, the determination of best-fit S/N curves with their associated standard deviations and the determination of the significance of differences between groups of results, different S/N curves and the determination of best common slopes and the intercepts of such curves. A computer program developed to perform the necessary calculations is outlined. Examples are given of the types of results produced by this analysis and of certain difficulties in the interpretation.

VARIATIONAL METHODS

79-1903

The Structure of Equations in Elastokinetics and Elastic Stability (Zur Struktur der Gleichungen der Elastokinetik und Elastostabilitat)

H. Bufler
Institut f. Mechanik (Bauwesen) der Univ. Stuttgart, Pfaffenwaldring 7, Stuttgart 80, West Germany,
Z. angew. Math. Mech., 59 (2), pp 73-78 (Feb 1979) (In German)

Key Words: Variational methods, Stability, Vibration response

Variational equations governing incremental quantities are derived from d'Alembert's principle and its generalizations. From these equations, an approximate solution of continuous vibration and stability problems is obtained, resulting in Lagrange's equations of the discrete substitute system.

FINITE ELEMENT MODELING

(Also see Nos. 1996, 2050, 2051)

79-1904

A Finite Element Approach to the Dynamic Contact Problem

N.H. Madsen
Ph.D. Thesis, The Univ. of Iowa, 151 pp (1978)
UM 7912882

Key Words: Finite element technique, Dynamic analysis

The thesis considers the application of finite element techniques to dynamic contact problems. A procedure for the solution of problems of this type is derived. This procedure determines the region of contact between two bodies for each instant of the contact. The contact forces and the displacements of each of the two bodies are also obtained.

MODELING

(Also see No. 2103)

79-1905

Displacement Oscillation in Plane Quadratic Isoparametric Elements in Orthotropic Situations

J.S. Holt and P.S. Hope
Dept. of Mech. Engrg., Univ. of Leeds, Leeds, UK,
Intl. J. Numer. Methods Engr., 14 (6), pp 913-920 (1979) 7 figs, 1 table, 8 refs

Key Words: Orthotropism, Mathematical models, Oscillation

Long thin test specimens of orthotropic material are modeled by quadratic isoparametric finite elements in plane strain. The displacement oscillations are predicted by the ill-conditioning of the structural stiffness matrix measured by a solution diagonal decay factor.

DIGITAL SIMULATION

79-1906

Application of Model Algorithmic Control to a Lightly Damped Single Input Single Output System

H.J. Colson, Jr.
School of Engrg., Air Force Inst. of Tech., Wright-Patterson AFB, OH,
Rept. No. AFIT/GE/EE/78-21, 111 pp (Dec 1978)
AD-A064 222/3GA

Key Words: Active control, Flutter, Digital techniques

A digital control technique, called Model Algorithmic Control (MAC), is applied to a single-input single-output model containing complex eigenvalues. The MAC algorithm developed is a simplified version of the algorithm used by ADERSA/GERBIOS Corporation (France) in a complete computer program designated IDCOM (Identification and Command). A second-order model based on the dominant eigenvalues of the B52E Flutter Mode is selected as the hypothetical

system to be controlled. Data is obtained for various selections of control parameters in the implementing program, then a study is made of the controlling program's robustness to eigenvalue changes.

PARAMETER IDENTIFICATION

(Also see No. 1982)

79-1907

Identification of Parameters in Distributed Systems Using Finite Element Method

H. Sehitoglu

Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 89 pp (1978)

UM 7913607

Key Words: Parameter identification technique

A method is presented for the identification of parameters in distributed systems governed by parabolic and hyperbolic partial differential equations. The method uses finite element approach to reduce the system's governing equation into a set of ordinary differential equations. A suitable performance index is then minimized by using a gradient method. The proposed method requires measurement of the field variable at a small number of points in the solution domain. Also, a radial flow problem with a boundary condition is considered.

79-1908

Identification of the Dynamic Characteristics of a Structure with Coulomb Friction

G.R. Tomlinson and J.H. Hibbert

Dept. of Mech., Production and Chemical Engrg., Manchester Polytechnic, Manchester M1 5GD, UK, J. Sound Vib., 64 (2), pp 233-242 (May 22, 1979) 6 figs, 14 refs

Key Words: Parameter identification technique, Method of harmonic balance, Coulomb friction

The effect of coulomb friction on the Kennedy and Pancu vector plot of a single degree-of-freedom system is analyzed by using the method of harmonic balance. A technique, based upon the in-phase and quadrature power dissipated when exciting a normal mode, is presented. The technique is also applied to systems having several degrees-of-freedom. The theoretical results are compared with experimental data from a structure containing a nonlinear coulomb device.

CRITERIA, STANDARDS, AND SPECIFICATIONS

79-1909

Evaluation Criteria for Balancing of Flexible Rotating Bodies (Beurteilungsmassstäbe f. den Auswuchtzustand rotierender nachgiebiger Körper)

A. Giers

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320 - VDI Verlag GmbH - Düsseldorf 1978, pp 55-60, 1 fig, 3 tables, 5 refs

(In German)

Key Words: Standards and codes, Rotors (machine elements), Balancing techniques

The progress of ISO on balancing standards of flexible rotors is described. It discusses the evaluation criteria for the limits of vibration of bearings and shafts, and the evaluation criteria for the limits of the equivalent residual unbalance in natural modes of the rotor under discussion.

79-1910

Application of the ISO Load Capacity Calculation Method to Turbine Drives (Anwendung der ISO-Tragfähigkeitsberechnung auf Turbogetriebe)

M. Hirt and H. Stockmaier

Leiter derGrundlagentechnik und Berechnung bei der Carl Hurth Maschinen- und Zahnradfabrik, München, Konstruktion, 31 (1), pp 41-47 (Jan 1979) 5 figs, 5 tables, 13 refs

(In German)

Key Words: Standards, Gears

The ISO Standard for the calculation of load capacity of spur gears is presented and special requirements for the turbine drive applications are explained. The standard is compared to other standards such as AGMA and API.

79-1911

Evaluation of Noise from Portable Air Tools

E. I. Auerbach

Ingersoll-Rand Co., Liberty Corner, NJ, S/V, Sound Vib., 13 (3), pp 14-17 (May 1979) 6 figs, 1 table, 6 refs

Key Words: Standards, Tools, Noise measurement

The historical background of air tool noise evaluation standards is described.

79-1912

Noise Abatement Zones: A Method for Controlling Noise from Fixed Premises

W.A. Utley

Dept. of the Environment, Bldg. Research Establishment, Bldg. Res. Station, Garston, Watford, WD2 7JR, UK, Noise Control Engr., 12 (3), pp 134-138 (May/June 1979) 2 figs, 11 refs

Key Words: Noise reduction, Regulations

In 1976, local authorities in England and Wales were given new powers to control noise from fixed premises. The procedures which involve setting up a noise abatement zone are described.

SURVEYS AND BIBLIOGRAPHIES

79-1913

Tracked Air Cushion Vehicles and Magnetic Levitation. Volume 1. 1970-1975 (Citations from the Engineering Index Data Base)

G.E. Habercom, Jr.

National Technical Information Service, Springfield, VA, 220 pp (Apr 1979)

NTIS/PS-79/0274/5GA

Key Words: Bibliographies, Ground effect machines, Suspension systems (vehicles), Ride dynamics

The feasibility, design, and track dynamics of tracked air cushioned and magnetically levitated vehicles are investigated in these abstracts of reports gathered in a worldwide literature survey. (This updated bibliography contains 212 abstracts, none of which are new entries to the previous edition.)

79-1914

Tracked Air Cushion Vehicle and Magnetic Levitation (Citations from the NTIS Data Base)

G.E. Habercom, Jr.

National Technical Information Service, Springfield, VA, 143 pp (Apr 1979)

NTIS/PS-79/0273/7GA

Key Words: Bibliographies, Ground effect machines, Suspension systems (vehicles), Ride dynamics

The feasibility, design, and track dynamics of tracked air cushioned and magnetically levitated vehicles are investigated in these Government-sponsored research reports. (This updated bibliography contains 135 abstracts, 8 of which are new entries to the previous edition.)

79-1915

Tracked Air Cushion Vehicles and Magnetic Levitation. Volume 2. 1976 - February 1979 (Citations from the Engineering Index Data Base)

G.E. Habercom, Jr.

National Technical Information Service, Springfield, VA, 87 pp (Apr 1979)

NTIS/PS-79/0275/2GA

Key Words: Bibliographies, Ground effect machines, Ride dynamics

The feasibility, design, and track dynamics of tracked air cushioned and magnetically levitated vehicles are investigated in these abstracts of reports gathered in a worldwide literature survey. (This updated bibliography contains 81 abstracts, 17 of which are new entries to the previous edition.)

79-1916

Aerodynamic Forces on Motor Vehicles (Citations from the NTIS Data Base)

G.E. Habercom, Jr.

National Technical Information Service, Springfield, VA, 67 pp (May 1979)

NTIS/PS-79/0392/5GA

Key Words: Bibliographies, Motor vehicles, Aerodynamic loads

Aerodynamic lift, drag, and side forces exerted on moving motor vehicles are investigated in these Government-sponsored research reports. Forces acting on passing vehicles as well as those acting under and around individual moving vehicles are reviewed. (This updated bibliography contains 60 abstracts, 9 of which are new entries to the previous edition.)

79-1917

Shock and Vibration Instrumentation

R. Plunkett

Aeronautics and Engrg. Mechanics, Univ. of Minnesota, Minneapolis, MN 55455, Shock Vib. Dig., 11 (6), pp 23-24 (June 1979) 8 refs

Key Words: Reviews, Vibration measurement, Shock measurement, Measuring instruments

This article briefly describes recent developments in instrumentation used to measure shock and vibration.

79-1918

Reduction Methods for Problems of Vibration of Orthotropic Plates. Part II: Generalized Reduction Method for Generally Orthotropic Plates with Arbitrary Shape

T. Sakata

Dept. of Mech. Engrg., Chubu Inst. of Tech., Kasugai, Nagoya-sub, 487 Japan, Shock Vib. Dig., 11 (6), pp 19-22 (June 1979) 1 table

Key Words: Reviews, Plates, Reduction methods, Natural frequencies

In this two-part article, Part I describes three exact reduction methods. Part II describes a generalized reduction method. The reduction method is used to derive an approximate formula for estimating the natural frequency of an orthotropic plate. The natural frequencies of the isotropic plate are used.

79-1919

Current Methods for Analyzing Dynamic Cable Response

H.J. Migliore and R.L. Webster

Portland State Univ., Portland, OR 97207, Shock Vib. Dig., 11 (6), pp 3-16 (June 1979) 115 refs

Key Words: Reviews, Cables (ropes), Lumped parameter method, Finite element technique, Method of weighted residuals

Various methods for analysis of cable dynamics are reviewed. Even though emphasis is given to developments in ocean cable analysis, much of the review has broader application. Static analytic methods are included because of their importance in dynamic solutions. Specific discussions are given on the lumped parameter and finite element methods and the method of weighted residuals.

79-1920

An International Survey of Shock and Vibration Technology

H.C. Pusey, R.H. Volin, and J.G. Showalter

Shock and Vibration Information Center, Washington, D.C., Mar 1979, Avail: SVIC, Naval Research Laboratory, Code 8404, Washington, D.C. 20375, Price $60.00 (US and Canada) $75.00 (Foreign)

Key Words: Reviews, Shock response, Vibration response, Acoustic response

The purpose of this study is to review and assess the state of shock and vibration technology in the United States and other Free World countries, to determine the relative status of this technology in the United States as compared to other countries, and to identify advances in foreign technology which could be used to complement domestic capabilities and Navy needs. Information examined in this study includes shock, vibration, acoustics and related dynamics areas from the standpoint of analysis, design, measurement, testing and application. Areas in which advancement is significant are emphasized. The technical output from all Free World countries is examined, but only those countries with significant interest in dynamics are discussed in this report. The very exhaustive work is based on about 7000 abstracts of technical papers and reports obtained from a search of the Shock and Vibration Digest and Data Base, as well as letters to investigators in the US and 21 other Free World countries.

79-1921

Vortex-Induced Oscillations. A Selective Review

T. Sarpkaya

Dept. of Mech. Engrg., Naval Postgraduate School, Monterey, CA 93940, J. Appl. Mech., Trans. ASME,

46 (2), pp 241-258 (June 1979) 15 figs, 3 tables, 134 refs

Key Words: Reviews, Vortex-induced vibration

This paper reviews the vortex-induced oscillations in a few specific fundamental cases. Research topics discussed are vortex shedding from a stationary bluff body; consequences of the synchronization phenomenon; wake-oscillator models; added mass, damping, and dynamic response measurements; flow-field models and the discrete-vortex method; mechanism of synchronization; and finally, in-line oscillations. Because of the selective nature of the review, a fairly comprehensive listing of recent contributions to the literature on these and related aspects of flow-induced oscillations research is an essential part of the exposition.

MODAL ANALYSIS AND SYNTHESIS

79-1922

A Nonparametric Identification Technique for Non-Linear Dynamic Problems

S.F. Masri and T.K. Caughey

Civil Engrg. Dept., Univ. of Southern California, Los Angeles, CA 90007, J. Appl. Mech., Trans. ASME, 46 (2), pp 433-447 (June 1979) 26 figs, 4 tables, 25 refs

Key Words: System identification technique, Modal analysis

A nonparametric identification technique is presented that uses information about the state variables of nonlinear systems to express the system characteristics in terms of orthogonal functions. The method can be used with deterministic or random excitation (stationary or otherwise) to identify dynamic systems with arbitrary nonlinearities, including those with hysteretic characteristics.

79-1923

Approximate Modal Analysis of Bilinear MDF Systems Subjected to Earthquake Motions

V. Tansirikongkol

Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 220 pp (1978)

UM 7913633

Key Words: Modal analysis, Multidegree of freedom system, Seismic excitation

The study investigates two approximate methods of modal analysis for hysteretic multi-degree-of-freedom lumped mass structural models subjected to earthquakes. The methods are: approximate modal analysis using elastic response spectra; and approximate modal analysis using inelastic response spectra. Both modal analysis procedures are iterative and use a perturbation method to successively modify the original elastic mode shapes at each iterative step to reflect yielding in the system. The procedures are developed and evaluated only for shear beam structural systems consisting of members with bilinear hysteresis.

COMPUTER PROGRAMS

GENERAL

79-1924

A Program for the Calculation of Torsional Vibrations (Programm zur Berechnung von Drehschwingungen)

H.-D. Klement

Wissenschaftlicher Mitarbeiter am Fachgebiet Maschinendynamik der TH Darmstadt, Konstruktion, 31 (2), pp 79-83 (Feb 1979) 8 figs, 1 table, 5 refs (In German)

Key Words: Computer programs, Torsional vibration, Natural frequencies, Transient vibrations, Modal analysis

A computer program for the calculation of a linear branched torsional vibration system is presented. In addition to the natural frequencies, stationary and transient vibrations are calculated. Modal analysis is used as a principal method of solution.

79-1925

A Critical Examination of a Numerical Fracture Dynamic Code

L. Hodulak, A.S. Kobayshi, and A.F. Emery

Dept. of Mech. Engrg., Washington Univ., Seattle, WA, Rept. No. TR-34, 30 pp (Feb 1979)

AD-A065 093/7GA

Key Words: Computer programs, Finite element technique, Fracture properties

After upgrading the energy dissipation algorithm, numerical experiments were conducted to assess the reliability of the explicit dynamic finite element code, HCRACK. Two dynamic fracture specimens, i.e., the wedge-loaded rectangular DCB (RDCB) specimen and the wedge-loaded tapered DCB (TDCB) specimen, were then analyzed with this updated fracture dynamic code.

79-1926

MASH - A Computer Program for the Non-Linear Analysis of Vertically Propagating Shear Waves in Horizontally Layered Deposits

P.P. Martin and H.B. Seed

Earthquake Engrg. Research Ctr., California Univ., Richmond, CA, Rept. No. UCB/EERC-78/23, NSF/RA-780545, 96 pp (Oct 1978)
PB-293 101/2GA

Key Words: *Computer programs, Soils, Earthquake response*

The computer program MASH is designed to analyze the dynamic response of a deposit of horizontal soil layers subjected to earthquake excitation. The deposit is discretized into a series of one-dimensional constant strain elements and the equations of motion are integrated with respect to time by the cubic inertia method.

79-1927

APOLLO - A Computer Program for the Analysis of Pore Pressure Generation and Dissipation in Horizontal Sand Layers During Cyclic or Earthquake Loading

P.P. Martin and H.B. Seed

Earthquake Engrg. Research Ctr., California Univ., Richmond, CA, Rept. No. UCB/EERC-78/21, NSF/RA-780543, 68 pp (Oct 1978)
PB-292 835/6GA

Key Words: Computer programs, Sands, Earthquake excitation

This report describes the computer program APOLLO, in which the method for the analysis of pore pressure generation and dissipation in horizontal sand layers during cyclic or earthquake loading has been incorporated, and gives a typical example of its application.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 1912, 1966, 2065)

79-1928

Sound Production Due to Large-Scale Coherent Structures

T.B. Gatski

NASA Langley Research Ctr., Hampton, VA, AIAA J., 17 (6), pp 614-621 (June 1979) 9 figs, 26 refs

Key Words: Sound generation, Turbulence

The acoustic pressure fluctuations due to large-scale finite amplitude disturbances in a free turbulent shear flow are calculated. The flow is decomposed into three component scales: the mean motion, the large-scale wave-like disturbance, and the small-scale random turbulence. The effect of the large-scale structure on the flow is isolated by applying both a spatial and phase average on the governing differential equations and by initially taking the small-scale turbulence to be in energetic equilibrium with the mean flow. The subsequent temporal evolution of the flow is computed from global energetic rate equations for the different component scales. Lighthill's theory is then applied to the region with the flowfield as the source and an observer located outside the flowfield in a region of uniform velocity.

79-1929

Effect of Sampling on the Statistical Descriptors of Traffic Noise

J.G. Vaskor, S.M. Dickinson, and J.S. Bradley

Faculty of Engrg. Science, The Univ. of Western Ontario, London, Ontario, Canada, Appl. Acoust., 12 (2), pp 111-124 (Mar 1979) 8 figs, 4 tables, 14 refs

Key Words: Traffic noise, Data processing, Statistical analysis

An empirical investigation of the errors in urban and transportation noise descriptors caused by the use of automatic monitoring sampling techniques is presented. Using eighteen selected continuous 24-h digital recordings of traffic noise, the common descriptors are computed for comparison with those computed from data sampled from the same recordings

in a manner simulating the digital and analogue automatic monitor sampling techniques by appropriate omission of data during analysis. Different time combinations for the digital sampling approach and different combinations of record time to non-record time for the analogue sampling approach are simulated. The discrepancies between the values of the descriptors from the sampled data and those from the continuous data are presented in graphical and tabular form.

79-1930

Noise Characteristics of Heated High Velocity Rectangular Jets

R.A. Kantola

Mechanics Branch, Mechanical Systems and Tech. Lab., General Electric Co., Corporate Res. and Dev., Schenectady, NY 12301, J. Sound Vib., 64 (2), pp 277-294 (May 22, 1979) 17 figs, 14 refs

Key Words: Jet noise

A comprehensive experimental investigation of the noise emission from a rectangular jet is carried out. This study is conducted with a wide range of jet velocities and temperatures. A substantial effort is made to present the information in this paper in such a fashion as to delineate the effects of turbulent mixing and acoustic shielding. A round jet with an equal area nozzle is also tested over the same ranges of velocity and temperature.

PERIODIC

(See Nos. 1894, 1897)

RANDOM

79-1931

Random Vibration and Stability of a Linear Parametrically Excited Oscillator

S.T. Ariaratnam and D.S.F. Tam

Faculty of Engrg., Solid Mech. Div., University of Waterloo, Waterloo, Ontario, Canada N2L 3G1, Z. angew. Math. Mech., 59 (2), pp 79-84 (Feb 1979)

Key Words: Random vibration, Stability, Oscillators, Parametric excitation, Forced excitation

The random vibration and stability of a linear second-order oscillator subjected to both parametric and forced excitations of small intensity are investigated. Using a method of stochastic averaging, the steady-state values of the response amplitudes as well as conditions for moment and sample stability are obtained. The first-passage problem for envelope crossing is also examined.

SEISMIC

(Also see No. 1923)

79-1932

Seismic Motion and Response Prediction Alternatives

C.A. Cornell, H. Banon, and A.F. Shakal

Dept. of Civil Engrg., M.I.T., Cambridge, MA, Intl. J. Earthquake Engr. Struc. Dynam., 7 (4), pp 295-315 (July/Aug 1979) 10 figs, 6 tables, 18 refs

Key Words: Statistical analysis, Seismic response

Statistical methods are available which predict the maximum response of simple oscillators given the peak acceleration, peak velocity, or peak displacement of seismic ground motions. An alternative parameter, namely an ordinate (or ordinates) of the Fourier amplitude spectrum of ground motion acceleration is discussed.

79-1933

Determination of the Seismic Design Parameters: A Stochastic Approach

J.B.U. Savy

Ph.D. Thesis, Stanford Univ., 223 pp (1979)
UM 7912407

Key Words: Seismic design, Stochastic processes

A model of release of the seismic energy in an earthquake is developed. The motion at the site created by the rupture of a patch is analytically found by using a dislocation model where the fault plane is assumed to be a geometrical discontinuity across which there exists a sudden discontinuity in the displacement vector. The characteristics of the dislocation are represented by a ramp function. The solution is limited in the present case to body S-waves generated by the small patch sources.

79-1934

Evaluation of Simulated Ground Motions for Predicting Elastic Response of Long Period Structures and Inelastic Response of Structures

A.K. Chopra and O.A. Lopez

Dept. of Civil Engrg., Univ. of California, Berkeley, CA, Intl. J. Earthquake Engr. Struc. Dynam., 7 (4), pp 383-402 (July/Aug 1979) 13 figs, 18 refs

Key Words: Seismic excitation, Ground motion, Simulation, Structural response

The response of linear elastic and non-linear hysteretic systems having a single degree of freedom to recorded and simulated ground motions is studied. The objective is to evaluate whether the commonly used simulated motions are appropriate for predicting inelastic response of structures and elastic response of long period structures. Eight simulated motions were generated to model properties of horizontal ground motions recorded during four earthquakes. The simulated motions are sample functions of a stationary, Gaussian white noise process, multiplied by a temporal intensity function and passed through a linear single-degree-of-freedom filter. Two versions, corresponding to parabolic and standard base line corrections of each of the simulated and recorded accelerograms were considered.

79-1935

Systems with Many Degrees of Freedom Under the Excitation of Non-Stationary Random Vibrations (Systeme mit vielen Freiheitsgraden bei Erregung durch nichtstationäre Zufallsschwingungen)

O. Henseleit and T. Hasse

Schwingungen von Maschinen und Bauwerken. Modellfindung. Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978. VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 205-210, 14 figs (In German)

Key Words: Seismic excitation, Random excitation, Computer programs, Finite element technique

The method for writing a post-processor for the Finite Element Program - System SAP IV is presented. With the program earthquake spectra of a given type may be obtained, giving a description of loads acting on the system.

79-1936

An Evaluation of Various Methods for the Analysis of Seismic Behavior of Light-weight Vibrating Systems (Bewertende Übersicht über verschiedenartige Verfahren zur Analyse des seismischen Verhaltens leichter schwingungsfähiger Systeme)

J. Jonczyk

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 173-186, 7 figs, 9 refs (In German)

Key Words: Seismic response, Vibrating structures, Machinery vibration, Nuclear power plants

A brief introduction of the main problems of the seismic behavior of vibrating structures is presented. An overview of earthquake resistant design of nuclear power plant machinery is discussed. Deterministic and stochastic methods for the dynamic analysis of the system -- the linear relationships of geometric, material, and damping properties -- are presented. A criteria for the evaluation of individual methods is also included.

79-1937

Method for the Design of Earthquake-Resistant Power Plants and the Possibilities for the Application of This Knowledge in General Plant Design (Verfahren zur Auslegung von Kernkraftwerken gegen Erdbeben und Möglichkeiten zur Nutzung dieser Erfahrungen im allgemeinen Anlagenbau)

P. Jehlicka

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 165-171, 8 refs (In German)

Key Words: Nuclear power plants, Seismic design

Fundamental methods for the determination of the effects of earthquakes in nuclear power plants are described.

SHOCK

79-1938

Blast Waves Produced by a Time-Dependent Energy Source

Y. Oved, F. Milinazzo, R.M. Clements, and P.R. Smy

Univ. of Victoria, Victoria, B.C., Canada, AIAA J., 17 (6), pp 601-605 (June 1979) 5 figs, 24 refs

Key Words: Shock waves

The dynamics of a spherical blast wave produced by an arbitrary time-dependent energy source are investigated both theoretically and experimentally. The blast wave in air is produced by an electrical discharge in a small cavity (a plasma jet used for internal combustion engine ignition). High-speed streak and Schlieren frame photography are used to measure the front of the self-luminous plasma and the shock wave, respectively. A numerical Eulerian model based on the gasdynamic equations in conservation form is used to predict positions of the luminosity front and the shock wave. Good agreement is obtained between theory and experiment.

PHENOMENOLOGY

COMPOSITE

79-1939

Analyses of Plates Constructed of Fiber-Reinforced Bimodulus Composite Material

J.N. Reddy and C.W. Bert

School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Oklahoma, Norman, OK 73019, Rept. No. OU-AMNE-79-8, 18 pp (June 1979)

Key Words: Composite materials, Fiber composites, Plates, Periodic excitation

To implement the structural application of the recently introduced fiber-governed symmetric compliance model for bimodulus composite materials, both classical closed-form and finite-element solutions are developed. This paper summarizes the results obtained for deflection of single-layer orthotropic and two-layer, cross-ply plates of the following configurations and loadings: thin elliptic plates clamped on the boundary and subjected to uniform pressure; and moderately thick rectangular plate freely supported on the boundary and subjected to sinusoidally distributed pressure.

79-1940

Mathematical Modeling and Micromechanics of Fiber-Reinforced Bimodulus Composite Materials

C.W. Bert

School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Oklahoma, Norman, OK 73019, Rept. No. OU-AMNE-79-7, 21 pp (June 1979)

Key Words: Composites, Fiber composites

In Part I of this report, various mathematical constitutive equations proposed to model the mechanical behavior of fiber-reinforced composite materials having different compliances in tension and compression are described and evaluated. Five different constitutive equations are described in detail and evaluated in the light of three criteria. In Part II of the report two entirely different micromechanistic approaches are developed to explain these observed differences in tension/compression behavior: the mean-fiber-angle approach originated by Tarnopol'skii et al. and the elastically supported tie-bar/column approach originated by Herrmann et al.

79-1941

Dynamic Testing of Discontinuous Fibre Reinforced Composite Materials

D.J. Nelson

Dept. of Mech. Engrg., Univ. of Glasgow, Glasgow G12 8QQ, UK, J. Sound Vib., 64 (3), pp 403-419 (June 8, 1979) 12 figs, 9 refs

Key Words: Composite materials, Fiber composites, Dynamic tests

The work reported is part of a larger study of the mechanics of discontinuous fiber reinforced composite materials – particularly those with interfacial slip. The materials used are models composed of aligned stub steel rods of 0-4 mm diameter and 25 mm length as fibers and a proprietary silicone rubber as matrix. The specimens, which are of low volume fraction, are in the form of square section rods and have other bonded or unbonded matrix/fiber interfaces. The tests conducted consisted of simple strain controlled tensile tests and the use of the specimens as the spring/damper element in a single degree of freedom system resonating near 20 Hz.

79-1942

Dynamic Behavior of Aircraft Materials

F.A. Bick and P. Van Blaricum

Effects Technology, Inc., Santa Barbara, CA, Rept. No. ETI-CR-78-485, DNA-4545F, 128 pp (Feb 1978) AD-A064 592/9GA

Key Words: Composites, Nuclear explosion effects

Dynamic, high strain rate loading characterization of two composite materials that are being used today in the design of military and commercial aircraft is accomplished. Of particular concern is the response of such materials to nuclear blast and thermal environments.

DAMPING

(Also see No. 1983)

79-1943

Response of a Base Excited System with Coulomb and Viscous Friction

M.S. Hundal

Dept. of Mech. Engrg., The Univ. of Vermont, Burlington, VT 05405, J. Sound Vib., 64 (3), pp 371-378 (June 8, 1979) 5 figs, 2 refs

Key Words: Coulomb friction, Viscous damping, Single degree of freedom systems, Harmonic excitation, Ground motion

The response of a single degree of freedom spring-mass system with viscous and Coulomb friction, with harmonic base excitation, is determined. Closed form analytical solutions of the equation of motion are found for two cases: continuous motion of the mass; and motion of mass with two stops per cycle. Results are presented in non-dimensional form as magnification factors versus frequency ratios as functions of viscous and Coulomb friction parameters.

FATIGUE

(Also see Nos. 1902, 1965, 1972, 1973, 1974)

79-1944

Calculation of Fatigue Life Related Vibrations of Impact Loaded Drive Systems (Lebensdauerbezogene Schwingungsberechnungen f. stossartig beanspruchte Antriebssysteme)

D. Wünsch and H. Gudehus

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 267-272, 9 figs, 10 refs

(In German)

Key Words: Fatigue life, Machinery vibration, Mathematical models

In the calculation of fatigue life of intermittent action machinery such as crane drives, rolling mill installations, etc., the stress-time function is needed. Since the measurement data needed for this function are difficult to obtain, a method for a mathematical vibration simulation is presented.

79-1945

A Realistic Computer-Based Fatigue Comparison of Spheroidal Graphite Cast Iron and Cast Steel

P. Watson and B.J. Dabell

GKN Group Technological Centre, Birmingham New Road, Wolverhampton WV4 63W, UK, Intl. J. Fatigue, 1 (2), pp 69-79 (Apr 1979) 20 figs, 13 refs

Key Words: Fatigue (materials), Computer aided techniques

Loads measured in a wheeled loader during service are used to compare two casts of SG iron with a cast steel to BS 592 grade A. Fatigue lives are predicted using computer based analytical methods. The conclusions reached are contrasted to those indicated by the more conventional static and fatigue tests. The suitability of SG iron as a material for cast axle housings is demonstrated.

79-1946

Some Initial Fatigue Tests on All-Carbon Fabric Laminates

L.N. Phillips and J.B. Sturgeon

Royal Aircraft Establishment, Farnborough, Hants GU14 6TD, UK, Intl. J. Fatigue, 1 (2), pp 66-68 (Apr 1979) 2 figs, 5 refs

Key Words: Fatigue tests, Fatigue (materials), Laminates

Fatigue tests are carried out on laminates prepared from all-carbon fabrics comprising tows of the same size in warp and weft, these being present in roughly equal amounts.

FLUID

(Also see Nos. 1921, 2004, 2047, 2067, 2069)

79-1947

Dynamic Analysis of Incompressible Viscous Liquids

G.R. Johnson
Defense Systems Div., Honeywell, Inc., Hopkins, MN 55343, J. Appl. Mech., Trans. ASME, 46 (2), pp 281-284 (June 1979) 4 figs, 5 refs

Key Words: Dynamic response, Liquids, Finite element technique

A Lagrangian finite-element analysis technique is presented for two-dimensional plane strain problems involving time-dependent incompressible flow of viscous liquids. The incompressibility feature is obtained with an iterative procedure which adjusts the nodal velocities until the anticipated volumetric strains are within specified limits. By eliminating the compressibility, it is possible to determine the integration time increment from the rate of distortion, rather than the sound speed transit time, as is required with various numerical methods involving wave propagation in compressible materials. This paper includes the formulation of the numerical method and illustrative examples.

SOIL

(Also see No. 1926)

79-1948

Analysis of Ground-Liner Interaction for Tunnels

R.E. Ranken
Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 443 pp (1978)
UM 7913583

Key Words: Tunnels, Tunnel linings, Interaction: soil-structure

As part of a research program sponsored by the Federal Railroad Administration, U.S. Department of Transportation, a study of the interaction between tunnel liner and surrounding ground mass was performed. Both analytical and numerical solution techniques were used to investigate ground-liner interaction for various loading conditions and construction sequences. The relationship between ground and liner material properties and the distributions of liner forces, stresses and displacements resulting from interaction is illustrated for a circular liner inserted in a stressed ground mass.

EXPERIMENTATION

BALANCING

(Also see No. 1909)

79-1949

T700 Power Turbine Rotor Multiplane/Multispeed Balancing Demonstration

G. Burgess and R. Rio
Mechanical Technology, Inc., 968 Albany-Shaker Rd., Latham, NY 12110, Rept. No. NASA-CR-159586, 45 pp (Feb 1979)
Sponsored by NASA

Key Words: Balancing techniques, Rotors, Turbine components

Experimental tests are conducted to demonstrate the ability of influence coefficient based multiplane/multispeed balancing to control rotor vibration through bending criticals. Rotor dynamic analyses are conducted of the General Electric T700 power turbine rotor.

79-1950

Experiments on Multiplane Balancing Using a Laser for Material Removal

R.S. DeMuth
Mechanical Technology, Inc., 968 Albany-Shaker Rd., Latham, NY 12110, Rept. No. MTI 78TR69, 43 pp (Feb 1979)

Key Words: Flexible rotors, Balancing techniques, Lasers, Computer aided techniques

This report describes the modification of a flexible rotor system for two-plane laser balancing. Experimental testing of the laser material removal method for balancing through the first bending critical speed is demonstrated. The test rig, optical configuration, and a neodymium glass laser system are assembled and calibrated for static and rotating material removal rates. The laser control computer program is combined with the influence coefficient balancing process.

79-1951
Modal Balancing of Elastic Rotors without Test Weights (Modales Auswuchten elastischer Läufer ohne Testgewichtssetzungen)
R. Gasch and J. Drechsler
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 45-54, 10 figs, 1 table, 12 refs
(In German)

Key Words: Rotors (machine elements), Balancing techniques, Modal tests, Modal analysis

A method for balancing elastic rotors without the use of test weights or test runs is described, in which the natural shapes and generalized masses are precalculated and are then used in the initial unbalance procedure of the experimental structural analysis.

79-1952
A New Method for the Calculation of Forced Vibrations of Elastic Rotors and its Application for Balancing (Ein neues Verfahren zur Berechnung von Zwangschwingungen elastischer Rotoren und Folgerungen f. das Auswuchten)
K. Kelkel
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 61-68, 7 figs, 7 refs
(In German)

Key Words: Rotors (machine elements), Forced vibration, Balancing techniques

Green's resolvent is presented as a new possibility for the calculation of forced vibrations of an elastic rotor. It gives, in a closed form, the forced vibration deflection at any rotor location caused by an unbalance at any location, independently of speed.

DIAGNOSTICS

(Also see No. 2093)

79-1953
Probabilistic Fault Diagnosis Models for Digital Systems
M.L. Blount
Ph.D. Thesis, Stanford Univ., 204 pp (1979)
UM 7912345

Key Words: Diagnostic techniques, Digital simulation

In this thesis, two diagnosis models, representing a new class of models called probabilistic diagnosis models, are presented for calculating the probability of correct system diagnosis. This calculated measure can be used to determine the coverage for the system and the availability of the system. The two models are intended for use in the distinct cases in which the final fault status decision is made by an entity internal to the system or external to the system.

79-1954
Fault Simulation, Analysis and Diagnosis of a Microprocessor
M.C. Schiffman
Ph.D. Thesis, Auburn Univ., 161 pp (1979)
UM 7913689

Key Words: Diagnostic techniques, Central processing units

A concise analysis procedure for a microprocessor is developed at the register and functional unit levels for learning how the microprocessor operates and determining its critical sections. Based on the results of the analysis procedure two fault diagnostic methods are developed.

79-1955
Effect of Diagonal Cracks on the Vibration of Rotors (Auswirkung von Querrissen auf das Schwingungsverhalten von Rotoren)
H. Ziebarth, H. Schwerdtfeger, and E.-E. Mühle
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 37-43, 10 figs, 8 refs
(In German)

Key Words: Rotors (machine elements), Crack detection, Diagnostic techniques

The effects of diagonal cracks on shafts are investigated. The crack is represented by a one-mass model describing the dependence of stiffness on angular velocity. An important

indication of crack development is the progressive change in vibration amplitudes with an increasing crack depth. Other crack development effects such as resonance, onset of unstable vibrations, and change in the components are considered as additional indications of damage.

79-1956

Vibration of a Cracked Turbine Rotor (Das Schwingungsverhalten eines angerissenen Turbinenläufers)

B. Grabowski

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 31-36, 12 figs, 7 refs

(In German)

Key Words: Diagnostic techniques, Rotors (machine elements), Turbine components, Shafts (machine elements)

In order to detect a crack on a turbine rotor from shaft vibration measurement, the effect of the crack on the vibration of a rotor must be known. A method is developed which uses modal analysis and a mathematical model representing the stiffness of the rotor at the location of the crack, dependent on angular velocity. In the article, a differentiation in the behavior of a gaping and a breathing crack is also made.

79-1957

Vibration Analysis and Nondestructive Testing Using Holographic Techniques

P.P. Hoffmann

Naval Postgraduate School, Monterey, CA, 76 pp (Dec 1978)

AD-A064 897/2GA

Key Words: Diagnostic techniques, Nondestructive tests, Holographic techniques, Plates, Rectangular plates, Plates

Real-time holograms are made of aluminum rectangular plates. The plates are cyclically vibrated with a piezoelectric driver to allow the fundamental frequencies to be measured and the mode shapes observed. The results are compared with theoretical frequency calculations.

79-1958

Assessment of Augmented Electronic Fuel Controls for Modular Engine Diagnostics and Condition Monitoring

D.R. Gilmore, Jr., H.J. Jordan, and A.D. Pisano

Aircraft Engine Group, General Electric Co., Lynn, MA, Rept. No. USARTL-TR-78-32, 150 pp (Dec 1978)

AD-A065 128/1GA

Key Words: Diagnostic techniques, Engines, Turbine engines

Fault isolation to the module and line replaceable unit (LRU) level by means of a Diagnostic and Condition Monitoring (D and CM) System integrated with a Full-Authority Digital Electronic Control (FADEC) is evaluated in this study. A preliminary assessment of the D and CM system parameters required for performing the diagnostic functions on the current T700 engine is also included in the study.

79-1959

Monitoring of Fatigue Loading on Rotor Systems and Related Components

D.P. Chappell

Aeromechanics Lab., Res. and Tech. Labs., USA AVRADCOM, Moffett Field, CA, J. Amer. Helicopter Soc., 24 (2), pp 47-53 (Apr 1979) 18 figs, 2 refs

Key Words: Rotors, Fatigue tests, Fatigue life, Computer aided techniques, Diagnostic techniques

This paper gives the results of structural methods research on the subjects of fatigue cycle counting, fatigue damage monitoring, and the effects of spectrum loading on fatigue life. An algorithm is proposed for computer processing of raw data to obtain empirical loading spectra and to estimate fatigue damage. Applications of analytical applied load spectra are illustrated. On the basis of Miner's Rule, along with the analytical applied load spectra, allowable load-cycle curves under spectrum loading are developed for various materials. Computer programs developed in connection with this research are summarized. The applications of these methods to real-time fatigue damage monitoring is discussed.

EQUIPMENT

79-1960

Test Stand for the Life Testing of Bolted Pipe Joints (Prüfstand f. die Lebensdauerprüfung von Rohrverschraubungen)

H. Peeken and W.U. Zammert
Institut f. Maschinenelemente und Maschinengestaltung an der RWTH, Aachen, Germany, Konstruktion, 30 (4), pp 137-140 (Apr 1978) 8 figs, 2 refs
(In German)

Key Words: Test stand, Joints (junctions), Piping systems

A test stand is described which enables test bolted pipe joints to be loaded simultaneously by dynamic hydraulic compression and by an alternating flexural load. Leakage of the joint is used as a failure criteria. Several experimental results are given.

79-1961

Vibration Exciter Design Variants; Vibration Test Machine. Part I. Vibration Test Machines with Mechanical Excitation (Konstruktive Losungsvarianten von Schwingantrieben; Anwendungsbeispiel Schwingprufmaschine. Teil 1: Schwingprufmaschinen mit *mechanischer Prüfkrafterzeugung*)

D. Findeisen and K. Federn
Entwicklung und Konstruktion in der Bundesanstalt f. Materialprufung, Berlin, Konstruktion, 30 (1), pp 1-9 (Jan 1978) 16 figs, 33 refs
(In German)

Key Words: Vibration tests, Test equipment, Mechanical excitation, Forced excitation

Several vibration test machinery design variants are discussed from the point of view of vibration input, their structural elements, and the gearing and control equipment. In this first part, mechanically excited vibration testing machines are discussed, in which the vibration is excited by the following means: forced vibration caused by an inserted spring; forced vibration without the spring; and resonant vibration excited by means of an unbalance.

79-1962

Vibration Exciter Design Variants; Vibration Test Machine. Part II. Vibration Test Machines with Hydraulic or Electrical Excitation (Konstruktive Losungsvarianten von Schwingantrieben; Anwendungsbeispiel Schwingprufmaschine)

D. Findeisen and K. Federn
Entwicklung und Konstruktion in der Bundesanstalt f. Materialprufung, Berlin, Konstruktion, 30 (2), pp 53-65 (Feb 1978) 33 figs, 69 refs
(In German)

Key Words: Vibration tests, Test equipment, Hydraulic equipment, Electromagnetic excitation, Electrodynamic shakers

In Part II of this article, design variants of hydraulically and electrically excited vibration test machines are described. Hydraulic excitations discussed are: forced excitation by means of a volumetrically driven pulsation; a pump generated forced excitation; valve-controlled forced excitation; and valve-controlled resonant excitation. Two types of electrical excitation based on the electromagnetic and electrodynamic principle include the resonance excitation by means of an electromagnetic vibration motor as a resonator, and the force on resonance excitation using the electrodynamic vibration motor as a shaker.

INSTRUMENTATION

(Also see No. 1917)

79-1963

Noise Suppression and Prevention in Piezoelectric Transducer Systems

J. Wilson
Endevco, San Juan Capistrano, CA, S/V, Sound Vib., 13 (4), pp 22-25 (Apr 1979) 9 figs

Key Words: Measuring instruments, Shock measurement, Vibration measurement

This article reviews the mechanisms of noise generation and suggests how such noise can be prevented or suppressed.

79-1964

AGARD Flight Test Instrumentation Series. Volume 9: Aeroelastic Flight Test Techniques and Instrumentation

AGARD, Neuilly-Sur-Seine, France, Rept. No. AGARD-AG-160-Vol-9; ISBN-92-835-1311-8, 50 pp (Feb 1979)
N79-20138

Key Words: Aircraft vibration, Flutter, Test equipment and instrumentation

The flight test instrumentation for determining the flutter behavior of an aircraft is presented. The mechanism of

flutter is reviewed and the following items are discussed: requirements which the type of excitation should obey in order to enable the determination of the flutter characteristics; possible means of excitation; appropriate instrumentation; and data analysis procedures.

79-1965

A Field Recording System with Applications to Fatigue Analysis

D. Socie, G. Shifflet, and H. Berns

Univ. of Illinois at Urbana-Champaign, IL 61801, Intl. J. Fatigue, 1 (2), pp 103-111 (Apr 1979) 17 figs, 13 refs

Key Words: Fatigue life, Recording instruments

Recent advances in analytical techniques for estimating fatigue crack initiation lives of structures and components have made fatigue analysis a valuable tool for design engineers. A means of collecting long term (months) data, using microcomputer devices, and interpreting the data in a manner useful to the engineer, is described. The role of fatigue and service history analysis in the overall product design analysis is reviewed and the requirement of a data collection system defined.

79-1966

Investigations into the Measurement and Analysis of Infrasound and the Development of a Measuring System (Untersuchungen zur Messung und Analyse von Infraschall und Entwicklung eines Messsystems)

R. Heinen

Institut f. Technische Akustik der Technischen Hochschule, Aachen, Acustica, 42 (2), pp 98-107 (Apr 1979) 12 figs, 14 refs

(In German)

Key Words: Measurement techniques, Measuring instruments, Sound measurement, Infrasonic frequencies

The following equipment and procedures for the measurement and analysis of infrasound are investigated: microphone, calibration apparatus, magnetic tape recording technique, procedures for frequency and wave analysis, filter and sound level measuring apparatus. The objective is to develop a measuring system for infrasound similar to that employed for audible sound investigations. The results of measurement are presented.

79-1967

The Use of Admittance Figures in the Processing of Acoustic Interferometry Measurements

A.R. Colclough

Div. of Quantum Metrology, National Physical Lab., Teddington, Middlesex, UK, Acustica, 42 (1), pp 18-27 (Mar 1979) 6 figs, 21 refs

Key Words: Acoustic techniques, Interferometers, Mechanical admittance

Following a discussion of the usual approximations employed in the impedance circle approach, analogous relations in terms of admittance are derived with the aid of some elementary theorems of conformal mapping theory.

79-1968

Nonlinearity Errors in Acoustic Interferometry

A.R. Colclough

Div. of Quantum Metrology, National Physical Lab., Teddington, Middlesex, UK, Acustica, 42 (1), pp 28-36 (Mar 1979) 3 figs, 21 refs

Key Words: Acoustic techniques, Interferometers, Error analysis

Three mechanisms leading to nonlinear transducer motion in the acoustic interferometer are discussed.

79-1969

A New Two-Dimensional Oscillating Wing Apparatus for Unsteady Aerodynamics Research

S.S. Davis and G.N. Malcolm

NASA Ames Research Ctr., Moffett Field, CA, In: NASA. Langley Res. Ctr., Advanced Tech. Airfoil Res., Vol. 1, Pt. 2, pp 671-688 (1978) N79-20004

Key Words: Test equipment and instrumentation, Aircraft wings

An apparatus for experimental research into unsteady transonic flows is described. The test wing is fully instrumented for dynamic waveform measurements and the data can be acquired, processed, and displayed in real-time with a new computational data acquisition system. Following a description of the apparatus, sample data from a recently completed test program is presented.

TECHNIQUES

(Also see Nos. 1966, 2109, 2110)

79-1970

Environmental Testing Under Random Loading

C.J. Dodds

MTS Systems Corp., Box 24012, Minneapolis, MN 55424, J. Test Eval. (ASTM), 7 (4), pp 232-237 (July 1979) 5 figs, 11 refs

Key Words: Data processing, Random excitation

A data reduction and analysis technique is presented for describing a multivariate nonstationary random process, representing a multiaxial stress distribution, by stationary techniques. An accurate simulation of this stress environment is achieved in the laboratory by using an iterative deconvolution technique to derive a series of excitation signals that will be used for fatigue testing.

79-1971

Excitation and Analysis Technique for Flutter Tests

G. Haidl and M. Steininger

Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany, Rept. No. AGARD-R-672, ISBN-92-835-1309-6, 31 pp (Jan 1979)

N79-20137

Key Words: Aircraft vibration, Flutter, Testing techniques, Computer programs

Excitation methods for flight flutter testing are surveyed. Examples of excitation by frequency sweep, pseudo-random, harmonic oscillation and control feedback technique are given and their effectiveness and adaptation to digital processing is discussed. Experience with generating aerodynamic forces by control-surfaces or additional vanes is presented. The digital analysis of flight flutter test data is described. Recommendations for selection of analysis parameters and how to avoid errors due to digital processing are given.

79-1972

Ultrasonic Test Samples of Different Materials with Equivalent Vibration Characteristics

P. Bajons

2 Physikal Institut, Univ. of Vienna, Vienna, Austria, Appl. Acoust., 12 (3), pp 181-185 (May 1979) 2 figs, 12 refs

Key Words: Ultrasonic techniques, Fatigue tests

A simple method of ultrasonic fatigue testing is described which makes possible the design of similar samples of different materials. The specimens have equivalent vibration characteristics and the same magnification factor.

79-1973

Developments in Hardware and Software for Computer Controlled Servohydraulic Fatigue Testing Systems

H. Nowack, D. Hanschmann, N. Baumhoff, and G. Jacoby

Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Institut f. Werkstoff-Forschung, 5 Koln 90, Federal Rep. of Germany, Intl. J. Fatigue, 1 (2), pp 93-102 (Apr 1979) 19 figs, 10 refs

Key Words: Fatigue tests, Computer aided techniques

This paper outlines typical ranges of applications for computers; the development of special hardware and software for use with servohydraulic fatigue test machines; and general trends regarding the use of computers in fatigue testing laboratories.

79-1974

Computer-Based Full Scale Fatigue Testing

D.K. Ewing

National Engrg. Lab. (NEL), East Kilbride, Galsgow G75 0QU, UK, Intl. J. Fatigue, 1 (2), pp 89-92 (Apr 1979) 11 figs, 6 refs

Key Words: Fatigue tests, Computer aided techniques

Computer-based methods can help to ease the difficulties of realistic full-scale testing by unravelling some of the complexities of multi-channel service loading simulation during the stages of data acquisition, data analysis and test rig control. The potential of these methods is illustrated by a simulated gun firing test – an extreme example which requires the facilities of three widely differing computer systems to carry out full-scale endurance tests.

79-1975

Correlation Procedures in Remote Measuring Techniques (Korrelationsverfahren in der Fernmesstechnik)

U. Kurze

Battelle Institut e.V., Frankfurt/Main, Acustica, 41 (5), pp 321-326 (Feb 1979) 3 figs, 3 refs

(In German)

Key Words: Frequency meters, Correlation techniques

A three-channel correlation of narrow-band signals is described, which serves for accurate frequency measurement and spatial direction finding. The evaluation of the general formula employs an algorithm suitable for quick digital data-processing. It concerns short-time correlation and an averaging technique.

79-1976

A Method for Measuring Small Displacements

B.Z. Sandler, A. Slonim, M. Slonim, A. Tslaf, and M. Weinberg

Dept. of Mech. Engrg., Ben Gurion Univ. of the Negev, Beer Sheva, Israel, Israel J. Tech., 16 (5-6), pp 234-237 (1978) 7 figs, 2 refs

Key Words: Vibration measurement, Measurement techniques, Lasers

This paper deals with measuring small mechanical oscillations or vibrations. A new approach in measuring by use of a laser beam which permits one to obtain stable results is described. An example of the application of the described method for measuring relay contact vibrations is given.

HOLOGRAPHY

(See No. 1957)

COMPONENTS

ABSORBERS

79-1977

The Inelastic Vibration Absorber Subjected to Earthquake Ground Motions

K.S. Jagadish, B.K.R. Prasad, and P.V. Rao

Dept. of Civil Engrg., Indian Inst. of Science, Bangalore, India, Intl. J. Earthquake Engr. Struc. Dynam., 7 (4), pp 317-326 (July/Aug 1979) 8 figs, 13 refs

Key Words: Vibration absorption (equipment), Seismic design, Buildings

Two story bilinear hysteretic structures are studied to explore the possibility of using the dynamic vibration absorber concept in earthquake-resistant design. The response of the lower story is optimized for the Taft 1952 accelerogram with reference to parameters such as frequency ratio, yield strength ratio and mass ratio. The influence of viscous damping is examined.

SHAFTS

79-1978

The Use of an Observer for an Accurate Determination of Torsional Vibrations (Einsatz eines Beobachters zur genauen Bestimmung von Torsionsschwingungen)

H. Wilharm and H. Fick

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 69-76, 12 figs, 7 refs

(In German)

Key Words: Torsional vibrations, Turbine components, Shafts (machine elements), Mathematical models

A procedure for the determination of torsional vibrations of turboshafting is described in which the mathematical model is supplemented by an observer and a filter.

79-1979

Calculation of Crank Drive Vibrations (Beitrag zur Berechnung der Schwingungen von Kurbelgetrieben)

E.O. Krämer

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 257-265, 17 figs, 7 refs

(In German)

Key Words: Crankshafts, Drive shafts, Equations of motion, Nonlinear systems

The advantages and disadvantages of introducing Liouville coordinates in the equations of motion and in the linearization methods for the analysis of drives is discussed.

79-1980

Forced and Parametric Excitation of Torsional Crankshaft Vibrations (Erzwungene und parametererregte Drehschwingungen in Kurbelwellen)

H. Krumm

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlage GmbH - Düsseldorf 1978, pp 87-93, 10 figs 4 refs

(In German)

Key Words: Torsional vibrations, Forced excitation, Parametric excitation, Crankshafts, Shafts (machine elements)

Torsional vibrations of crankshafts, which connect machinery exhibiting periodically variable inertia moments, are calculated. Computer programs are developed for the calculation of stability and stationary vibration of such systems, taking forced excitations and parametric excitations into consideration.

79-1981

Torsional Vibration Measurement of Crankshafts Using a Desk Calculator (Messung der Torsionsschwingungen von Kurbelwellen unter Verwendung eines Tischrechners)

H. Barsch and E. Hermanns

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 95-101, 3 figs, 4 refs

(In German)

Key Words: Shafts (machine elements), Crankshafts, Torsional vibration

Mobile measurement installation, digital data processing, calculation and presentation of frequency curves are discussed.

79-1982

System Identification of Crankshaft-Torsional Vibrations (Zur Systemidentifizierung bei Kurbelwellen-Drehschwingungen)

B. Schneider and M. Rack

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 103-108, 6 figs, 3 refs

(In German)

Key Words: Shafts (machine elements), Crankshafts, System identification technique

Measurement, characteristic points of frequency curve and optimum damping characteristics are discussed.

79-1983

Determination of Damping During Torsional Vibrations of Large Turboshafts (Erfassung der Dämpfung bei Torsionsschwingungen grosser Turbosätze)

H. Berger and T. Kulig

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 77-85, 12 figs, 5 refs

(In German)

Key Words: Electrical power plants, Turbine components, Shafts (machine elements), Fatigue life, Damped structures

A procedure for the calculation of damped torsional vibrations of turboshafts is described. Measurement results of power plant damping are also given.

BEAMS, STRINGS, RODS, BARS

(Also see No. 1919)

79-1984

Wood Beams Under Impact Load

B.D. Zakic

Inst. for Materials Testing, Beograd, Yugoslavia, ASCE J. Struc. Div., 105 (ST7), pp 1489-1507 (July 1979) 13 figs, 33 refs

Key Words: Beams, Impact response (mechanical)

An analysis of the behavior of glue-laminated wood beams under impact load in the elastic and plastic range is presented. The theoretical part of the study consists of the definition of the general methodology of solving the vibration of the system with a nonlinear ratio between force and deformations. The validity of the vibration design is verified by a testing program using full-size specimens. The test results obtained agree favorably with the theoretical predictions.

79-1985

A Note on the Lumped Parameter Beam Models Based on Mechanical Impedance

V.H. Neubert and V.P. Rangaiah
Pennsylvania State Univ., State College, PA 16801,
J. Sound Vib., 64 (3), pp 379-385 (June 8, 1979) 6 figs, 1 table, 6 refs

Key Words: Beams, Bernoulli-Euler method, Lumped mass method, Mechanical impedance, Mathematical models, Ground shock

Investigations of the three-parameter lumped mass model for a Bernoulli-Euler clamped-clamped beam are described. Numerical results for the transient response due to a low frequency ground shock are presented.

79-1986

The Influence of Rotatory Inertia and Transverse Shear on the Dynamic Plastic Behavior of Beams

N. Jones and J.G. de Oliveira
Dept. of Ocean Engrg., Massachusetts Inst. of Tech., Cambridge, MA 02139,
J. Appl. Mech., Trans. ASME, 46 (2), pp 303-328 (June 1979) 7 figs, 18 refs

Key Words: Beams, Rotatory inertia effects, Transverse shear deformation effects

The theoretical procedure presented herein examines the influence of retaining the transverse shear force in the yield criterion and rotatory inertia on the dynamic plastic response of beams. Exact theoretical rigid perfectly plastic solutions are presented for a long beam impacted by a mass and a simply supported beam loaded impulsively.

79-1987

On the Lateral Stability of a Cantilever Beam Subjected to a Non-Conservative Load

Z. Celep
Faculty of Engrg. and Architecture, Technical Univ., Istanbul, Turkey,
J. Sound Vib., 64 (2), pp 173-178 (May 22, 1979) 3 figs, 12 refs

Key Words: Cantilever beams, Lateral response, Follower forces, Flutter

In this paper vibration and stability of a cantilever beam subjected to vertical and follower loads are investigated. The eigencurves of the beam are presented for various values of the ratio of follower load to vertical and follower loads. The divergence and flutter instability loads of the beam are given for a wide range of the ratio.

79-1988

Inelastic Response of Beams Under Sinusoidal and Random Loads

R.N. Iyengar
Dept. of Civil Engrg., Indian Inst. of Science, Bangalore 560012, India,
J. Sound Vib., 64 (2), pp 161-172 (May 22, 1979) 8 figs, 19 refs

Key Words: Beams, Cantilever beams, Periodic excitation, Random excitation

A new analytical model is suggested for the hysteretic behavior of beams. Results are presented in the form of graphs for maximum deflection, bending moment and shear.

79-1989

A Simplified Method of Finding Equivalence Conditions in a Class of Distributed Parameter Systems

G.B. Mahapatra
Dept. of Electrical Engrg., Roorkee Univ., Roorkee, India 247672,
J. Franklin Inst., 307 (4), pp 209-215 (Apr 1979) 6 refs

Key Words: Bars, Continuous parameter method, Wave equations, Lateral vibration

A simplified method along with a proof is proposed in this paper to find the equivalence conditions in a class of linear distributed parameter systems. The proposed method is illustrated for diffusion equations; wave equations; and lateral vibrations of bars; all with three spatial coordinates.

79-1990

Influence of Mass Distribution on the Stability of Rods in the Presence of Polygenic Forces

H.H.E. Leipholz

Ing. Arch., 48 (3), pp 185-195 (1979) 10 figs, 4 refs

Key Words: Rods, Flutter, Follower forces

In this paper, the influence of a non-uniform mass distribution on the stability behavior of a rod subjected to follower forces is investigated. A condition is studied which ensures the absence of flutter instability. Corresponding conclusions are drawn for a rocket type rod system.

79-1991

Theoretical Study of the Dynamic Response of a Chimney to Earthquake and Wind

T.Y. Yang, L.C. Shiau, H. Lo, and J.L. Bogdanoff

School of Aeronautics and Astronautics, Purdue Univ., Lafayette, IN, Rept. No. NSF/RA-780527, 149 pp (Apr 1, 1978)

PB-293 561/7GA

Key Words: Chimneys, Wind-induced excitation, Earthquake resistant structures, Finite element technique, Computer programs

Analytical studies of the elastic and inelastic responses of a chimney to an earthquake are performed. The chimney studied is at the steam generating plant at Paradise, Kentucky of Tennessee Valley Authority. The report describes the geometry and the material property of the chimney at a TVA Power Plant. An existing computer program SAP IV is employed to study the elastic response of the chimney. Both time history and response spectrum analyses are employed to obtain the displacements and forces at various heights of the chimney. A simple method is developed to generate the ground response spectrum as the input data for the response spectrum analysis.

79-1992

Calculation of Transversal Cable Vibrations in Hauling Shafts (Berechnung der rheonomen transversalen Seilschwingungen von Schachtförderanlagen)

W. Stühler

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 133-141, 7 figs, 3 refs

(In German)

Key Words: Cables (ropes), Hoists, Materials handling equipment

A mathematical formulation of the response of cables in hauling shafts is presented. It includes simplified assumptions, time dependent boundary conditions, plotting of time vs cable motions, and stability calculations.

79-1993

Comparison of Theoretical and Experimental Analyses of the Dynamic Behaviour of a Plane Cable-Net Structure

J.H. Argyris, W. Aicher, and H. Flüh

Institut f. Static u. Dynamic d. Luft u. Raumfahrtkonstruktionen, Univ. Stuttgart, West Germany, Forsch. Ingenieurw., 45 (2), pp 37-50 (1979) 31 figs, 1 table, 9 refs

Key Words: Cables (ropes), Dynamic response

The dynamic behavior of an even cable-net structure is analyzed with the help of process computers. The measuring and modular program systems are described and results of the experimental analysis are shown. The latter are compared with a theoretical investigation, which was carried out with the finite element method. The agreement of theory and experiment is demonstrated graphically.

79-1994

Dynamic Response of a Print Belt System

P.A. Engel, H.C. Lee, and J.L. Zable

IBM System Products Div. Lab., P.O. Box 6, Endicott, NY 13760, IBM J. Res. Dev., 23 (4), pp 403-410 (July 1979) 9 figs, 1 ref

Key Words: Belts (moving), Printing devices, Mathematical models

The dynamic response of a print belt system, when the print belt is subjected to impuslive print forces, is analyzed in this paper. The system consists of a flat steel print belt tightly wrapped around pulleys with one of the pulleys driven by a motor. Analytical modeling allows the prediction and analysis of belt motion and thus the prediction of print misregistration. Discrete parameters used in the analysis

permit simulation of the belt motion as affected by variations in belt tension, stiffness, pulley inertias, and motor-operating parameters. Conditions of belt slippage are examined, as well as the effect of dynamic loading upon the drive motor.

79-1995

The Stability of a Moving Elastic Strip Subjected to Random Parametric Excitation

F. Kozin and R.M. Milstead
Dept. of Electrical Engrg., Polytechnic Inst. of NY, Brooklyn, NY 11201, J. Appl. Mech., Trans. ASME, 46 (2), pp 404-410 (June 1979) 8 figs, 15 refs

Key Words: Dynamic stability, Moving strips, Random excitation, Parametric excitation

The dynamic stability of a thin strip, travelling axially, at a constant speed between two roller supports is investigated for the case of zero mean random in-plane loading. Galerkin's method is used to reduce the equations of motion to a set of fourth-order stochastic equations. Results in terms of the variance of the random loadings on the moving strip are derived.

BEARINGS

(Also see No. 2114)

79-1996

Calculation of a Rubber-Metal Bearing with Structural Elements (Berechnung eines Gummimetallagers mit Strukturelementen)

J. Völckers
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 159-164, 7 figs, 1 table, 1 ref
(In German)

Key Words: Rubber bearings, Automobiles, Finite element technique, NASTRAN (computer program)

A finite element technique for a quick and accurate calculation of the required stiffness of rubber-metal bearings for structural elements is presented. The technique is demonstrated in the calculation of the stiffness of rubber-metal bearings for automobile axles. NASTRAN computer program is used.

BLADES

79-1997

Rotor Blade Stability in Turbulent Flows - Part I

Y.K. Lin, Y. Fujimori, and S.T. Ariaratnam
Univ. of Illinois at Urbana-Champaign, IL, AIAA J., 17 (6), pp 545-552 (June 1979) 1 fig, 1 table, 25 refs

Key Words: Blades, Rotary wings, Helicopters, Turbulence, Statistical analysis

The effect of turbulence in the atmosphere on the motion stability of a helicopter blade is investigated. Modeling turbulence as a random field, statistically stationary in time and homogeneous in space, the method of stochastic average of Stratonovich is used to obtain equivalent Itô stochastic equations, from which the Fokker-Planck equation for the transition probability density and the equations for various stochastic moments can be derived.

79-1998

Methodical Measures for Modifying the Frequencies of Torsional Blade Vibrations (Gezielte Massnahmen zur Verlagerung der Torsionsfrequenzen einer Axialschaufel)

G. Ziegler
Nürnberger Weg 21, 4755 Holzwickede, MTZ Motortech. Z., 40 (5), pp 253-255 (May 1979) 2 figs, 1 table, 2 refs
(In German)

Key Words: Blades, Torsional vibration, Geometric effects

A method of calculation for the required change in the thickness of a given turbine blade to modify its torsional frequency is presented.

79-1999

Analysis of High Velocity Impact on Hybrid Composite Fan Blades

C.C. Chamis and J.H. Sinclair
NASA Lewis Research Ctr., Cleveland, OH, Rept. No. NASA-TM-79133; E-9979, 17 pp (1979)
N79-20398

Key Words: Fan blades, Aircraft engines, Computer programs, Impact response (mechanical)

Recent developments in the analysis of high velocity impact of composite blades are described, using a computerized capability which consists of coupling a composites mechanics code with the direct-time integration features of NASTRAN. The application of the capability to determine the linear dynamic response of an interply hybrid composite aircraft engine fan blade is described in detail.

79-2000

Structural Dynamics, Stability and Control of High Aspect Ratio Wind Turbine Generators

F.S. Stoddard

Ph.D. Thesis, Univ. of Massachusetts, 318 pp (1979) UM 7912722

Key Words: Dynamic stability, Wind turbines, Turbine blades, Computer programs

The blade dynamics and vibration of wind turbine generators with high aspect ratio (slender) blades are developed. Equations of motion are derived, and blade motions and forces are found, for degrees of freedom in flapping, lead-lag, and feathering subject to gravity, crosswind, yaw rate, and axisymmetric aerodynamic forces. Tower degrees of freedom are added to assess tower loads and vibration. Significant mechanical and aeroelastic instabilities are predicted and discussed. Methods are developed, and quantitative computer programs are given, for the structural and vibration analysis of twisted, tapered, composite shell blades. The University of Massachusetts Wind Furnace I, which is the impetus of this study, is described.

79-2001

Rotor Blade Stability in Turbulent Flows - Part II

Y. Fujimori, Y.K. Lin, and S.T. Ariaratnam

Univ. of Illinois at Urbana-Champaign, IL, AIAA J., 17 (7), pp 673-682 (July 1979) 2 figs, 1 table, 8 refs

Key Words: Rotor blades, Aerodynamic loads, Turbulence

This paper is directed toward the effect of turbulence in the atmosphere on the rotor blade stability during a forward flight. Two types of motion are considered: uncoupled flapping, and coupled flapping and torsion. The method of the Markov process is applied in the formulation of the problem. The results are presented as stability boundaries for the first- and second-order stochastic moments corresponding to different spectral levels of the excitations. The stability boundaries for the nonturbulence case, previously obtained from deterministic analyses, are also included for comparison.

CONTROLS

79-2002

Analysis of Failure of Compressor Multi-Ring Valve Plates

R.M. Weir

School of Mech. and Offshore Engrg., Robert Gordon's Inst. of Tech., Schoolhill, Aberdeen, Instn. Mech. Engr. Proc., 193, pp 53-59 (Mar 1979) 17 figs, 10 refs

Key Words: Valves, Compressors, Failure analysis

An analysis of failure of compressor multi-ring valve plates is made.

79-2003

Increase Pump Seal Life

L. McNally

Sealol, Inc., Providence, RI, Hydrocarbon Processing, 58 (1), pp 107-111 (Jan 1979) 6 figs

Key Words: Seals (stoppers), Pumps

A systematic approach to troubleshooting seals that can extend seal life dramatically is described.

CYLINDERS

(See No. 2006)

DUCTS

79-2004

Flow in Straight Ducts of Arbitrary Cross Section

P.W. Duck

Dept. of Aeronautical and Astronautical Engrg., The Ohio State Univ., Columbus, OH 43210, J. Appl. Mech., Trans. ASME, 46 (2), pp 263-268 (June 1979) 8 figs, 1 table, 7 refs

Key Words: Ducts, Fluid mechanics

A method is presented for treating flows in straight ducts. The method involves the conformal mapping of the cross section onto a semicircle, and then solving the problem using Fourier series.

79-2005

Sound Propagation and Radiation Through a Vaneless Diffuser

T. Nagashima and Y. Tanida
Inst. of Space and Aeronautical Science, Univ. of Tokyo, Tokyo, Japan, J. Sound Vib., 64 (3), pp 439-449 (June 8, 1979) 9 figs, 4 refs

Key Words: Ducts, Sound propagation

A simple analysis is carried out to examine acoustic effects of attaching to the termination of an annular duct a vaneless diffuser through which incident plane waves propagate and radiate out circumferentially. The results are shown in the form of a reflection coefficient which expresses the ratio of the incident and reflected waves at the diffuser inlet.

79-2006

A Note on the Radiation Impedance of a Circumferential Slit in a Circular Cylinder

T. Nagashima and Y. Tanida
Inst. of Space and Aeronautical Science, Univ. of Tokyo, Tokyo, Japan, J. Sound Vib., 64 (3), pp 433-438 (June 8, 1979) 5 figs, 5 refs

Key Words: Circular cylinders, Cylinders, Ducts, Sound waves, Wave propagation

The modal radiation impedance of a circumferential opening in a circular cylinder is obtained as a simple integral formula. Calculation results are presented, demonstrating the effects of the width/radius ratio of the opening.

79-2007

The Noise Reduction of the Acoustic Paths Between Two Rooms Interconnected by a Ventilation Duct

R.J.M. Craik
Dept. of Bldg., Heriot-Watt Univ., Chambers St., Edinburgh, EH1 1HX, UK, Appl. Acoust., 12 (3), pp 161-179 (May 1979) 11 figs, 11 refs

Key Words: Ventilation, Ducts, Sound transmission, Statistical energy analysis, Noise reduction

This paper describes measurements made on a system of two rooms separated by a wall but connected by a ventilation duct. Using statistical energy analysis the noise reduction of each path through the system is determined from the measured data.

FRAMES, ARCHES

79-2008

Simple Models for Computing Dynamic Responses of Complex Frame Structures

C.C. Chen, C.T. Sun, J.L. Bogdanoff, and H. Lo
School of Aeronautics and Astronautics, Purdue Univ., Lafayette, IN, Rept. No. NSF/RA-780529, 96 pp (Apr 1978)
PB-292 798/6GA

Key Words: Framed structures, Electric power plants, Earthquake resistant structures, Finite element technique, Timoshenko theory, Mathematical models

The development of a simple shear beam and a Timoshenko base model for dynamic analysis of complex frame structures is described. Formulas are derived for computing the equivalent shear and bending rigidities of the structure.

79-2009

Elastic Stability of a Simple Frame Subjected to a Circulatory Load

D.E. Panayotounakos and A.N. Kounadis
National Technical Univ., Athens, Greece, J. Sound Vib., 64 (2), pp 179-186 (May 22, 1979) 2 figs, 20 refs

Key Words: Frames, Flutter

An analytical procedure for establishing critical loads of nonconservative frames is illustrated through a simple two-bar frame subjected to a circulatory compressive force.

79-2010
Spatial Antisymmetrical Vibrations and Stability of Circular Arches with Flexibly Supported Ends
Y. Wasserman
Dept. of Mech. Engrg., Ben Gurion Univ. of the Negev, Beer Sheva, Israel, Israel J. Tech., 16 (5-6), pp 224-233 (1978) 4 figs, 7 tables, 10 refs

Key Words: Arches, Natural frequencies

In this work, exact formulae are obtained for determining the lowest natural frequencies and critical loads of elastic circular arches with flexibly supported ends for antisymmetrical vibration in the direction perpendicular to the plane of the initial curvature of the arch. The investigation is concerned with three cases of load behavior during the process of deformation.

GEARS
(Also see No. 1910)

79-2011
Attacking Gear Noise at the Mesh
W.S. Rouverol
Rolling Contact Gear Co., Berkeley, CA, Mach. Des., 51 (10), pp 68-71 (May 10, 1979) 9 figs

Key Words: Gears, Noise reduction, Design techniques

Eleven design features which will help reduce gear noise at the mesh are described. Each feature reduces noise either by increasing total contact ratio, improving kinematic accuracy, or by reducing pitch-line velocity.

79-2012
Friction of Sliding and Rolling Pairs in Dry Run or With Border Lubrication (Reibung in Gleit-Walzpaarungen bei Trockenlauf oder Grenzschmierung)
M. Mette
Institut f. Konstruktionslehre, Maschinen- und Feinwerkelemente der TU Braunschweig, Konstruktion, 30 (7), pp 259-266 (July 1978) 9 figs, 5 refs (In German)

Key Words: Gears, Rolling friction, Sliding friction

Experimental results are presented for the evaluation of the sliding behavior of friction pairs with partial sliding and rolling.

ISOLATORS

79-2013
Testing of a Wind Restraint for Aseismic Base Isolation
J.M. Kelly and D.E. Chitty
Earthquake Engrg. Research Ctr., California Univ., Berkeley, CA, Rept. No. UCB/EERC-78/20, NSF/RA-780542, 47 pp (Oct 1978)
PB-292 833/1GA

Key Words: Vibration isolators, Seismic design, Buildings, Dynamic tests

This report describes an extensive series of shaking table tests. The wind restraint consisted of a notched shear pin. Several shear pins were tested in conjunction with a natural rubber isolation system placed beneath a three-story 40,000 lb. steel frame model structure. Pins with breaking forces ranging from 3% to 20% of the weight of the model were tested. The model structure was subjected to various peak accelerations of three earthquake inputs. The design of a shear pin mechanical fuse system for a full-scale structure is discussed in view of the experimental results described.

LINKAGES

79-2014
Load Capacity and Spring Rate of Shaft Couplings with Flexible Universal Joints (Tragfähigkeit und Federsteifen von Wellenkupplungen mit federnden Laschengelenken)
F. Jarchow and R. Sturmath
Ordinarius am Lehrstuhl f. Maschinenelemente und

Getriebetechnik der Ruhr-Universität, Bochum, Konstruktion, 31 (1), pp 33-40 (Jan 1979) 17 figs, 2 refs
(In German)

Key Words: Universal joints, Flexible joints

Equations for the calculation of forces, moments and stresses in the plates of flexible universal joints are developed. In addition, equations for torsional spring, axial spring, and angular spring stiffnesses of the universal joint are derived. By means of an experimentally derived design strength diagram by Smith, information for load capacity is obtained.

79-2015
Vibration Damping by Means of Hysteresis in Screw and Riveted Joints (Untersuchungen zur Schwingungsdampfung durch Hysterese in Schraub- und Nietverbindungen)
D. Ottl
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH-Düsseldorf 1978, pp 249-255, 5 figs, 4 refs
(In German)

Key Words: Joints (junctions), Hysteretic damping

Experiments with screw joints in tension and flexure are carried out. The mechanical behavior can be simulated only by means of nonlinear models. For vibration systems with such damping properties, quasilinear differential equations may be used, which are solved by means of the Krylow-Bogoljubow-Mitropolsky averaging method. In this manner, free vibrations and resonant vibrations of a one-dimensional continuum are solved.

79-2016
Optimum Transmission of Elastic Waves Through Joints
B. Lundberg, R. Gupta, and L.E. Andersson
Dept. of Mech. Engrg., Univ. of Lulea, S-951 87 Lulea, Sweden, Wave Motion, 1 (3), pp 193-200 (July 1979) 7 figs, 7 refs

Key Words: Joints (junctions), Elastic waves, Wave propagation

An elastic wave transmitting system (e.g., a nonuniform elastic rod) consisting of an input section with constant impedance, a joint with variable impedance, and an output section with constant impedance is considered. The efficiency of energy transmission (the ratio of transmitted to incident elastic wave energy) is determined and the following optimization problem is solved for two sample cases.

MECHANICAL

79-2017
The Nonsteady Elastohydrodynamics (Die instationare Elastohydrodynamik)
J. Holland
Inhaber des Lehrstuhls f. Reibungstechnik und Maschinenkinetik sowie Direktor des gleichnamigen Instituts der TU Clausthal, Konstruktion, 30 (9), pp 363-369 (Sept 1978) 6 figs, 9 refs
(In German)

Key Words: Lubrication, Machinery components

The article reviews current techniques for the calculation of lubricating film thickness in the elastohydrodynamic range under intermittent loading. Such loading and operational conditions occur frequently in numerous machine elements, so that a more accurate determination of lubricating film is of great importance.

PANELS

79-2018
Acoustic Impedance of Rectangular Panels
Y.M. Chang and P. Leehey
Acoustics and Vibration Lab., Massachusetts Inst. of Tech., Cambridge, MA 02139, J. Sound Vib., 64 (2), pp 243-256 (May 22, 1979) 7 figs, 2 tables, 15 refs

Key Words: Rectangular panels, Acoustic impedance

The modal radiation impedance of a rectangular panel simply supported in an infinite baffle in the presence of an inviscid, uniform, subsonic flow is determined. The analysis is based on an expansion in normal modes of the transverse vibration displacement field of the panel and the use of wavenumber-

frequency transforms. Integral expressions for the modal radiation impedance and the cross-modal coupling impedance are formulated. A Gaussian quadrature with reusable abscissas is developed to evaluate these modal radiation impedances. Changes with respect to flow speed in modal radiation damping of a rectangular membrane are measured.

subjected to the NS component of the ground acceleration in the El Centro 1940 earthquake record are obtained. The effects of damping, the material stiffness, and the frame structure on the piping responses are investigated.

79-2019

Aspects of the Reflexion and Free Wave Properties of a Composite Panel Under Fluid Loading

D.G. Crighton
Dept. of Applied Mathematical Studies, Univ. of Leeds, Leeds LS2 9JT, UK, J. Sound Vib., 64 (4), pp 467-474 (June 22, 1979) 1 table, 4 refs

Key Words: Panels, Composite materials, Fluid-induced excitation

The response of a composite panel to external forcing, with inclusion of fluid loading effects, is considered. The behavior of the acoustic field close to grazing incidence is examined, this behavior being determined by that of the plane wave reflexion coefficient. A discussion is given of the possible importance of the high wavenumber mode in the case of excitation by high wavenumber boundary layer turbulence, and of the significance of two free subsonic surface wave modes in calculations of energy transmission over composite panels of the kind modeled here.

PIPES AND TUBES

(Also see No. 1960)

79-2020

Dynamic Response of High Pressure Steam Pipe in a Fossil Fuel Power Plant

C.T. Sun, H. Lo, J.L. Bogdanoff, and Y.F. Chou
School of Aeronautics and Astronautics, Purdue Univ., Lafayette, IN, Rept. No. NSF/RA-780530, 54 pp (Apr 1978)
PB-292 553/5GA

Key Words: Piping systems, Nuclear power plants, Earthquake response, Damping effects

The dynamic behavior of a high pressure steam pipe in the fossil fuel power plant of Unit No. 3 of the Tennessee Valley Authority at Paradise, Kentucky is investigated. Free vibrations are first studied. Dynamic responses of the system

79-2021

Insulation of Structure-Borne Sound in Pipelines (Untersuchungen zur Körperschalldämmung bei Rohrleitungen)

W. Kuhl and H. Wollherr
Am Reisenbrook 7a, 2000 Hamburg 67, Germany, Acustica, 42 (1), pp 37-46 (Mar 1979) 12 figs, 9 refs (In German)

Key Words: Machinery noise, Sound transmission, Pipelines, Buildings

Several means for the reduction of machinery noise transmitted to the buildings via pipelines are investigated. They are damping the noise path at pipeline intersections; isolating the pipes from the building; insulating structural joints; and damping of floors. By measuring the tubes with very different diameters the impedance effect of compensators, distributor cylinders, and mass barriers is obtained.

79-2022

Fast-Acting Valves for Use in Shock Tubes (Part 2, Formation of Shock Waves)

T. Ikui, K. Matsuo, and Y. Yamamoto
Faculty of Engrg., Kyushu Univ., Fukuoka, Japan, Bull. JSME, 22 (167), pp 693-699 (May 1979) 11 figs, 10 refs

Key Words: Shock tubes, Shock waves

In the previous paper, two kinds of fast-acting valves were developed to replace diaphragm-breaking as a means of generating shock waves in the conventional shock tubes. One of them, called a type-H valve is used in a shock tube in this paper, and the strength of shock waves generated by the valve and the correlation between the shock formation distance and the opening time of the valve are experimentally clarified. The experiments where a diaphragm is used are also performed, keeping all other operating conditions equal, and the results are compared with those by the valve.

79-2023
Stability Boundaries for Flow Induced Motions of Tubes with an Inclined Terminal Nozzle
T.S. Lundgren, P.R. Sethna, and A.K. Bajaj
Dept. of Aerospace Engrg. and Mechanics, Univ. of Minnesota, Minneapolis, MN 55455, J. Sound Vib., 64 (4), pp 553-571 (June 22, 1979) 6 figs, 18 refs

Key Words: Tubes, Fluid-filled containers, Flutter, Perturbation theory

A theoretical and experimental study is made of self-induced non-planar vibrations of a flexible tube conveying a fluid. The tube is fixed at one end and the fluid issues from a nozzle inclined to the axis of the tube at the free end. The results of the analysis are presented in terms of stability boundaries as a function of the system parameters.

79-2024
Interpretation of Gas Oscillations in Multicylinder Fluid Machinery Manifolds by Using Lumped Parameter Descriptions
R. Singh and W. Soedel
Ray W. Herrick Labs., School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Sound Vib., 64 (3), pp 387-402 (June 8, 1979) 5 figs, 6 tables, 20 refs

Key Words: Manifolds, Tubes, Fluid-induced excitation, Acoustic response, Lumped parameter method

The multicylinder interaction problem is formulated in the frequency domain. Mass flow rates, with proper crank phase relationships, are considered excitation sources. Manifold components are described as acoustic elements. The equations of acoustic motion are solved for the eigenvalues and the natural modes of gas oscillation, and these are used to provide the forced acoustic response. The formulations are then applied to a two-cylinder compressor discharge system. The computed results compare well with measurements.

PLATES AND SHELLS

(Also see Nos. 1918, 1939, 2050, 2051)

79-2025
Reduction of Sound Generation and Radiation by Plates Caused by Impact Excitation (Verringerung der Schallentstehung und Abstrahlung von Platten bei Stossformiger Anregung)
A. Peeck
D-3061 Wiedensehl 96, Hannover, West Germany, Appl. Acoust., 12 (2), pp 81-92 (Mar 1979) 5 figs, 6 refs
(In German)

Key Words: Plates, Impact shock, Sound generation

The sound power level for shocks applied to plates is calculated approximately and noise reducing parameters are derived from theoretical relations.

79-2026
Free Wave Propagation in Two-Dimensional Periodic Plates
D.J. Mead and S. Parthan
Dept. of Aeronautics and Astronautics, Univ. of Southampton, Southampton, S09 5NH, UK, J. Sound Vib., 64 (3), pp 325-348 (June 8, 1979) 12 figs, 5 tables, 15 refs

Key Words: Plates, Wave propagation

The propagation of flexural waves in a two-dimensional periodic plate which rests on an orthogonal array of equispaced simple line supports is investigated. A type of plane wave motion is considered. An energy method is developed to predict the frequency of wave propagation in terms of the propagation constants. A Galerkin type of analysis is used, incorporating assumed complex modes of wave motion for the identical rectangular elements of the periodic plate.

79-2027
Non-Linear Vibration of a Centrally Clamped Rotating Disc
D.S. Dugdale
Dept. of Mech. Engrg., Univ. of Sheffield, UK, Intl. J. Engr. Sci., 17 (6), pp 745-756 (1979) 4 figs, 3 tables, 9 refs

Key Words: Disks (shapes), Normal modes, Natural frequency, Nonlinear response

Deflection profiles are calculated for vibration modes with up to four nodal diameters. Strain energy at large amplitudes is calculated. Calculated frequency-response curves compare well with experimental curves.

79-2028

Vibration and Stability of Spinning Polar Orthotropic Annular Plates Reinforced with Edge Beams

C.T. Dyka and J.F. Carney, III
Uniroyal Inc., Middlebury, CT 06749, J. Sound Vib., 64 (2), pp 223-231 (May 22, 1979) 7 figs, 9 refs

Key Words: Circular plates, Rings, Beam-plate systems, Natural frequencies, Buckling

In this paper, the frequencies and buckling loads for a radially compressed, spinning polar orthotropic annular plate with simply supported edge beams along the inner and outer edges are determined. The inner and outer edge beams are subjected to uniform radial loadings and the system spins at a constant angular velocity. The frequencies and buckling loads are determined for both axisymmetric and higher modes.

79-2029

Axisymmetric Vibrations of Linearly Tapered Annular Plates Under an In-Plane Force

U.S. Gupta and R. Lal
Dept. of Mathematics, Univ. of Roorkee, Roorkee, India, J. Sound Vib., 64 (2), pp 269-276 (May 22, 1979) 7 figs, 1 table, 10 refs

Key Words: Circular plates, Rings, Variable cross section, Natural frequencies, Axisymmetric vibrations

Analysis and numerical results are presented for the axisymmetric vibrations of circular annular plates with linear variation in thickness under the action of a hydrostatic in-plane force on the basis of the classical theory of plates. The governing differential equation with variable coefficients is solved by Chebyshev collocation technique. The effect of in-plane force on the natural frequencies of vibration is investigated for two different boundary conditions and for different radii ratio and taper constant. Transverse displacements, moments and the critical buckling loads in compression with thickness variation are also computed for the first two modes.

79-2030

Axisymmetric Non-Linear Oscillations of Isotropic Layered Circular Plates

V.X. Kunukkasseril and S. Venkatesan
Fibre Reinforced Plastics Research Ctr., J. Sound Vib., 64 (2), pp 295-302 (May 22, 1979) 6 figs, 10 refs

Key Words: Circular plates, Layered materials, Nonlinear response

Non-linear equations of motion for isotropic layered circular plates are presented for axisymmetric motion. Further simplification is made by ignoring the in-plane and rotatory inertia terms. Explicit solutions are obtained for the forced and free oscillations. Numerical results are presented for the case of a two layered plate of aluminium and steel.

79-2031

Transverse Vibration of a Circular plate on an Eccentric Annular Elastic Support

K. Nagaya, Y. Hirano, and K. Okazaki
Faculty of Engrg., Yamagata Univ., Yonezawa, Japan, Bull. JSME, 22 (167), pp 642-647 (May 1979) 5 figs, 2 tables, 3 refs

Key Words: Plates, Circular plates, Elastic foundation, Flexural vibration

This paper discusses vibration problems of a circular plate on an eccentric annular elastic support. The exact solution for the equation of motion is applied, and the boundary conditions at the edge of the plate are satisfied by means of the Fourier expansion method. The frequency equation for a plate with a clamped edge is obtained, and numerical calculations are carried out for some examples in these problems.

79-2032

Moving Load on Initially Stressed Thick Plates Attached Together by a Flexible Core

S. Chonan
Ing. Arch., 48 (3), pp 143-154 (1979) 13 figs, 3 refs

Key Words: Plates, Sandwich structures, Traveling loads, Transverse shear deformation effects, Rotatory inertia effects

Vibrations of an infinitely long, prestressed double strip-plate system are studied analytically. The plates are attached together by a flexible core and one of the plates is subjected to a line load which moves with a constant speed along the plate. The constant, uniform prestresses are parallel to and perpendicular to the infinite edges of the plates. The solution is presented within the framework of a plate theory which includes the effects of shear deformation and rotary inertia. Critical characteristic parameters of the system are defined. An example is provided where the bending moments of the plates are calculated.

79-2033

Transverse Vibrations of Rectangular Anisotropic Plates with Edges Elastically Restrained Against Rotation

P.A.A. Laura and R.O. Grossi

Inst. of Appl. Mechanics, Base Naval Puerto Belgrano, 8111-Argentina, J. Sound Vib., 64 (2), pp 257-267 (May 22, 1979) 2 figs, 10 tables, 12 refs

Key Words: Anisotropy, Rectangular plates, Flexural vibration

The present paper deals with an approximate solution of the title problem by use of very simple coordinate functions, which partially satisfy the boundary conditions, and the Ritz method. Values of the fundamental frequency coefficient and the one corresponding to the first fully antisymmetric mode are determined as a function of the edge spring coefficients.

79-2034

Response Using the Rayleigh-Ritz Method

G.B. Warburton

Dept. of Mech. Engrg., Univ. of Nottingham, Nottingham, UK, Intl. J. Earthquake Engr. Struc. Dynam., 7 (4), pp 327-334 (July/Aug 1979) 5 tables, 15 refs

Key Words: Plates, Rectangular plates, Harmonic excitation, Rayleigh-Ritz method

As an example of the extension of the Rayleigh-Ritz method to response calculations, an analysis is outlined for a clamped rectangular plate. For harmonic excitation amplitudes of displacement and bending moment are compared with values from a modal solution from the plate equation.

79-2035

Finite-Element Analysis of Composite-Material Plates

J.N. Reddy

School of Aerospace, Mech. and Nuclear Engrg., Univ. of Oklahoma, Norman, OK 73019, Rept. No. OU-AMNE-79-9, 37 pp (June 1979)

Key Words: Plates, Rectangular plates, Composite materials, Fiber composites, Shear deformation effects, Transverse shear deformation effects, Finite element technique

A finite-element formulation of the equations governing the laminated anisotropic plate theory of Yang, Norris, and Stavsky, is presented. The theory is a generalization of Mindlin's theory for isotropic plates to laminated anisotropic plates and includes shear deformation and rotary inertia effects. Finite-element solutions are presented for rectangular plates of antisymmetric angle-ply laminates having material properties that are typical of a highly anisotropic composite material.

79-2036

Vibration of Rectangular Plates Subjected to In-Plane Forces by the Finite Strip Method

H.C. Chan and O. Foo

Middlesex Polytechnic, Enfield EN3 4SF, UK, J. Sound Vib., 64 (4), pp 583-588 (June 22, 1979) 4 figs, 6 refs

Key Words: Rectangular plates, Plates, Finite strip method, Vibration response

The finite strip method is applied to the vibration analysis of rectangular plates subjected to in-plane forces. Several numerical examples are presented and comparison with available solutions clearly indicates the accuracy and efficiency of the method.

79-2037

Forced Vibrations of a Non-Uniform Thickness Rectangular Plate with Two Free Sides

T. Sakata and Y. Sakata

Dept. of Mech. Engrg., Chubu Inst. of Technology, Kasugai, Nagoya-sub, Japan 487, J. Sound Vib., 64 (4), pp 573-581 (June 22, 1979) 2 figs, 13 refs

Key Words: Rectangular plates, Plates, Variable cross section, Forced vibration

A forced vibration of a rectangular plate with thickness varying linearly in one direction is studied. The plate is simply supported along two opposite sides, and is free along the other sides. Approximate formulae are proposed for estimating the maximum deflection and surface stresses of a rectangular plate subject to a uniformly distributed harmonic lateral load. The accuracy of the formulae is discussed.

79-2038

Free Vibration and Transient Forced Response of Integrally Stiffened Skew Plates on Irregularly Spaced Elastic Supports

N.C. Bhandari, B.L. Juneja, and K.K. Pujara

Dept. of Mech. Engrg., Indian Inst. of Tech., Delhi, India, J. Sound Vib., 64 (4), pp 475-495 (June 22, 1979) 4 figs, 47 refs

Key Words: Skew plates, Plates, Free vibration, Transient response, Modal analysis

This paper deals with the vibration of integrally stiffened skew plates on irregularly spaced elastic supports. An approximate analysis to obtain the natural frequencies and mode shapes for different edge conditions is presented, in which Lagrange's equations are used. The responses to an exponentially decaying impact load and a half sine wave transient load of a supported skew plate are determined by modal analysis, with use of the frequencies and the normalized mode shapes thus obtained.

79-2039

Axisymmetric Transients in Shells of Revolution

D.P. Thambiratnam, A.H. Shah, and H. Cohen

Dept. of Civil Engrg., Univ. of Manitoba, Winnipeg, Canada, Intl. J. Earthquake Engr. Struc. Dynam., 7 (4), pp 369-382 (July/Aug 1979) 8 figs, 27 refs

Key Words: Shells of revolution, Transient response

The propagation of axisymmetric transients in shells of revolution subjected to impulsive boundary loads is treated in this paper. Consideration is restricted to linear, elastic, isotropic, homogeneous shells of revolution with straight line generators. The analysis is based on the concept of a wave as a carrier of discontinuities in the field variable and its derivatives. These discontinuities are determined from a set of recurrence relations which are in turn generated by the use of asymptotic series solutions to the equations of motion. A numerical superposition technique which enables the calculation of long time response is developed. Several numerical examples are presented in order to illustrate the method.

79-2040

Dynamic Elasto-Plastic Response of Shells in an Acoustic Medium. Theoretical Development for the EPSA Code

R. Atkatsh, M.P. Bieniek, and M.L. Baron

Weidlinger Associates, NY, Rept. No. TR-24, 77 pp (July 1978)

AD-A064 102/7GA

Key Words: Shells, Elastic-plastic properties, Computer programs

The EPSA (Elastic-Plastic Shell Analysis) code is developed for the analysis of shells in an acoustic medium subjected to dynamic loadings which produce large elasto-plastic deformations in the shell. The analysis includes the modeling of significant internal structures, which produce hard spots on the shell. In addition, the effects of ambient pressure are considered. This report presents the theoretical development for the EPSA code and a description of the code itself.

79-2041

Some Recent Advances in the Dynamics of Thin Elastic Shells Linear Theory

M. Dikmen

Istanbul Tech. Univ., Istanbul, Turkey, Intl. J. Engr. Sci., 17 (6), pp 659-680 (1979) 2 tables, 40 refs

Key Words: Shells, Elastic properties

Asymptotic methods to simplify the governing differential equations are presented. The results obtained for the case of quasi-transverse vibrations are discussed. Caustics are investigated by introducing an Airy function representation.

79-2042

Axisymmetric Vibration of Prestressed Non-Uniform Cantilever Cylindrical Shells

J.T.S. Wang, J.H. Armstrong, and D.V. Ho

Georgia Inst. of Technology, Atlanta, GA 30332, J. Sound Vib., 64 (4), pp 529-538 (June 22, 1979) 5 figs, 2 tables, 15 refs

Key Words: Shells, Cylindrical shells, Cantilever shells, Axisymmetric vibration, Variable material properties, Natural frequencies, Mode shapes

The extended Galerkin method is used in the investigation of axially loaded clamped-free homogeneous, isotropic and elastic cylindrical shells. Both mass and stiffnesses are considered to vary along the longitudinal direction. Legendre polynomials are used as shape functions which lead to a simple and systematic procedure in determining the natural frequencies and mode shapes. Some numerical results are given.

79-2043

Dynamic Buckling of a Damped Externally Pressurized Imperfect Cylindrical Shell

D.F. Lockhart
Dept. of Mathematics, Michigan Technological Univ., Houghton, MI 49931, J. Appl. Mech., Trans. ASME, 46 (2), pp 372-376 (June 1979) 1 fig, 1 table, 12 refs

Key Words: Shells, Cylindrical shells, Dynamic buckling

The dynamic buckling of a finite damped imperfect circular cylindrical shell which is subjected to step-loading in the form of lateral or hydrostatic pressure is examined by means of a perturbation method. An asymptotic expression for the dynamic buckling load is obtained in terms of the damping coefficient and the Fourier component of the imperfection in the shape of the classical buckling mode. A simple relation which is independent of the imperfection is then obtained between the static and dynamic buckling loads.

79-2044

Wide-Band Random Axisymmetric Vibration of Cylindrical Shells

I. Elishakoff, A.Th. van Zanten, and S.H. Crandall
Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Appl. Mech., Trans. ASME, 46 (2), pp 417-422 (June 1979) 6 figs, 3 tables, 16 refs

Key Words: Shells, Cylindrical shells, Random vibration

Analytical and numerical results are reported for the random vibrations of a uniform circular cylindrical shell excited by a ring load which is uniform around the circumference and random in time. The time history of loading is taken to be a stationary wide-band random process.

79-2045

The Vibrations of a Thin-Walled Elastic Cylinder Under Axial Stress

J.R. Thompson and A.J. Willson
Dept. of Mathematics, Univ. of Leicester, UK, Intl. J. Engr. Sci., 17 (6), pp 725-733 (1979) 3 figs, 11 refs

Key Words: Cylindrical shells, Axisymmetric vibrations

The dispersion equation governing the axisymmetric vibrations of an elastic thin-walled cylinder under axial stress is derived and its solutions, together with their implications for stability, are discussed. Numerical results are given for a material with a strain-energy function of Ko form.

79-2046

Circumferential Waves for a Cylindrical Shell in Smooth Contact with a Continuum

H.I. Epstein
Dept. of Civil Engrg., Univ. of Connecticut, Storrs, CT 06268, J. Sound Vib., 64 (2), pp 209-221 (May 22, 1979) 7 figs, 14 refs

Key Words: Cylindrical shells, Transverse shear deformation effects, Rotatory inertia effects, Wave propagation

Dispersion relations are determined for circumferential waves propagating in a layered, circular cylinder by using shell equations to approximate the behavior of the outer layer. These equations include the effects of transverse shear deformation and rotatory inertia. The cylinder consists of an elastic core in smooth contact with a hollow, circular cylinder of distinctly different elastic properties.

79-2047

Simplified Calculation of Natural Frequencies of Thick-Walled Cylinders in Air and Water

D. Guicking and R. Boisch
Drittes Physikalisches Institut der Universitat Gottingen, Acustica, 42 (2), pp 89-97 (Apr 1979) 3 figs, 3 tables, 13 refs
(In German)

Key Words: Shells, Cylindrical shells, Natural frequencies, Fluid-induced excitation

The natural frequencies are determined according to one of the thin-shell theories. The frequency reduction by the added mass of the surrounding medium is also calculated for the equivalent plate, its finite dimensions being accounted for by corrections applied to the value for the infinite plate.

STRUCTURAL

79-2048

Free Vibration of Frame Shear Wall Structures on Flexible Foundations

Y.K. Cheung and S. Swaddiwudhipong

Dept. of Civil Engrg., Univ. of Hong Kong, Hong Kong, Intl. J. Earthquake Engr. Struc. Dynam., 7 (4), pp 355-367 (July/Aug 1979) 11 figs, 5 tables, 16 refs

Key Words: Walls, Elastic foundations, Free vibration, Finite strip method

The finite strip method is used to study the effect of an elastic foundation on the natural frequencies of coupled frame shear wall structures. The solid wall in the structure is divided into several strip elements, the column is treated as a line element and the effect of the connecting beams is dealt with through the compatibility matrices which transfer their structural properties to the adjacent strip or line elements. A series of numerical examples is presented to show the accuracy and applicability of the proposed method.

79-2049

Earthquake Resistant Structural Walls - Tests of Coupling Beams. Final Report

G.B. Barney, K.N. Shiu, B.G. Rabbat, A.E. Fiorato, and H.G. Russell

Construction Technology Labs., Portland Cement Assn., Skokie, IL, Rept. No. PCA-R/D-SER-1583, NSF/RA-780501, 152 pp (Jan 1978)

PB-293 542/7GA

Key Words: Walls, Beams, Earthquake resistant structures

Eight model reinforced concrete coupling beam specimens are subjected to reversing loads representing those that would occur in beams of coupled structural walls during a severe earthquake. Effects of selected variables on hysteretic response are determined. Controlled variables include shear span-to-effective depth ratio of the beams, reinforcement details, and size of the confined concrete core.

79-2050

Design Techniques for the Control of Structure-Borne Noise of Plate and Box Structures (Part I: Homogeneous Plates) (Beeinflussung des Korperschallverhaltens von Platten- und Kastenstrukturen durch konstruktive Gestaltung (Teil I: Homogene Platten)

E.G. Welp

Jagenberg Werke AG, Düsseldorf, war wissenschaftlicher Mitarbeiter am Fachgebiet Maschinenelemente und Getriebe der TH Darmstadt, Konstruktion, 30 (9), pp 353-361 (Sept 1978) 4 figs, 1 table (In German)

Key Words: Plates, Machinery components, Structural members, Noise reduction, Design techniques, Finite element technique

The vibration and frequency-dependent structure-borne noise of homogeneous plate structures is investigated using the finite element technique. The results of the investigation are used in the design of quieter machinery parts.

79-2051

Design Techniques for the Control of Structure-Borne Noise of Plate and Box Structures (Part II: Inhomogeneous Plate and Box Structures) (Beeinflussung des Korperschallverhaltens von Platten- und Kastenstrukturen durch konstruktive Gestaltung (Teil 2: Inhomogene Platten- und Kastenstrukturen)

E.G. Welp

Jagenberg Werke AG, Düsseldorf, war wissenschaftlicher Mitarbeiter am Fachgebiet Maschinenelemente und Getriebe der TH Darmstadt, Konstruktion, 30 (11), pp 456-464 (Nov 1978) 13 figs, 13 refs

(In German)

Key Words: Plates, Box type structures, Machinery components, Structural members, Noise reduction, Design techniques, Finite element technique

Using the finite element technique, the vibration and frequency-dependent structure-borne noise of inhomogeneous plate, cube and parallel piped box structures is investigated. The results of the investigation enable the design of quieter machinery parts.

SYSTEMS

ABSORBER

79-2052

The SUSPA Solid-Media Impact Shock-Absorber, System Menasco (Der SUSPA-Feststoff-Aufprall-dampfer)

H. Siegner

Am Eichenhain 8, 8503, Rothenbach, Automobiltech. Z., 81 (5), pp 229-230 (May 1979) 5 figs
(In German)

Key Words: Energy absorption, Bumpers, Automobiles

Impact shock-absorbers with solid damping-media are described. They are mounted in a horizontal position between the bumper and the car body.

79-2053
What's Available in Cylinder Cushions
Hydraulics & Pneumatics, 32 (5), pp 78-80 (May 1979)

Key Words: Springs (elastic), Energy absorption, Impact shock, Isolation

Hydraulic and pneumatic cylinder manufacturers are surveyed for design approaches to cylinder cushioning. Some of the methods used are described.

79-2054
How to Specify Cushioning in Mill-Type Cylinders
G. Hoobler
Lincoln Machine Co., Inc., Salem, OH, Hydraulics & Pneumatics, 32 (5), pp 76-77 (May 1979)

Key Words: Impact shock, Isolation, Energy absorption

This article combines standard formulas, rules of thumb, common sense, and experience to outline procedures to help select heavy duty mill cylinders. These procedures can be used to find the maximum loading conditions for a specific cylinder size, or, conversely, bore and rod size, and cushion length for a given load and speed.

79-2055
An Analysis of Hydraulic Cylinder Cushioning
B.N. Murali
Mech. Res. and Dev. Dept., Halliburton Services, Duncan, OK, Hydraulics & Pneumatics, 32 (5), pp 72-75 (May 1979) 4 figs

Key Words: Impact shock, Isolation, Energy absorption

This article describes the basic principle of cushioning, shows several cushion configurations, and then uses a mathematical model to track the pressure changes present at a typical cylinder cushion.

79-2056
Broad Band Attenuation for Stochastically Excited Vibration Systems (Breitbandtilger f. stochastisch erregte Schwingungssysteme)
H. Bräutigam and W. Wedig
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 195-204, 6 figs, 7 refs
(In German)

Key Words: Vibration control, Vibration tuning, Random excitation, Automobiles

Wide band vibration attenuation of weakly damped systems is investigated. The method used is applied in the analysis of vehicle and structural dynamics.

79-2057
An Application of Beam Dynamics to a Damper Design
H.C. Lee and J.W. Raider
IBM Office Products Div. Lab., Lexington, KY 40507, IBM J. Res. Dev., 23 (4), pp 386-391 (July 1979) 5 figs, 3 refs

Key Words: Energy absorption, Beams, Printing devices

Flexural wave propagation is used as a means of absorbing impact energy to prevent excessive rebound or to shorten the cycle time of high-speed printing devices. For optimal damping action, the dynamic analysis of beams used in the mechanism is necessary; this paper presents such an analysis. It also presents an application of a damper ring design that is used to prevent shadow printing by suppressing the rebound of the type elements in a disk printer.

NOISE REDUCTION

(Also see Nos. 2007, 2021, 2088, 2105)

79-2058

Determination of Modulus of Elasticity and the Dissipation Factor of Rubber Elements in the Acoustic Range (Bestimmung des Elastizitätsmoduls und des Verlustfaktors von Gummielementen im akustischen Frequenzbereich)

W. Gerwig

Fachgebiet Maschinenelemente und Getriebe der TH Darmstadt, Darmstadt, Germany, Konstruktion, 31 (6), pp 241-247 (June 1979) 11 figs, 2 tables, 4 refs

(In German)

Key Words: Elastomers, Machinery components, Dissipation factor, Modulus of elasticity, Acoustic range, Noise reduction

For the reduction of structure-borne noise of rubber elements, the modulus of elasticity and the dissipation factor in the acoustic range must be known. Two procedures for the determination of these values are presented in which the rubber element is regarded as a massive continuum. The evaluation and the use of diagrams is illustrated by means of an example, and the results are compared to those obtained by DIN 53513.

79-2059

The Control of Diffracted Sound by Means of Thnadners (Shaped Noise Barriers)

L.S. Wirt

Lockheed California Co., Burbank, CA 91503, Acustica, 42 (2), pp 73-88 (Apr 1979) 30 figs, 10 refs

Key Words: Noise barriers, Noise reduction, Traffic noise

Scale model tests are described which display the trends predicted by the theory. Structures are suggested for the practical implementation of the method into noise barriers. A literary analogy suggests that such structures be called Thnadners.

79-2060

Noise Shielding from Traffic Noise by Structural Elements (Zur Abschirmwirkung von Bauelementen Gegenuber Strassenverkehrslarm)

W.-D. Knop

Fachhochschule Koln, Fachbereich Architektur, Koln, Fed. Dem. Rep., Appl. Acoust., 12 (3), pp 195-213 (May 1979) 14 figs, 12 refs

(In German)

Key Words: Noise barriers, Walls, Buildings, Traffic noise

Noise shielding by walls, buildings, and mounds is investigated by the use of models. The effect of absorption and reflection on screening is established.

79-2061

Silencer Development at TI Cheswick Silencers

Auto Engr. (UK), 4 (2), pp 43-45 (Apr/May 1979) 7 refs

Key Words: Silencers, Noise reduction, Ground vehicles

The development and configuration of heavy vehicle silencer units for quantity production are discussed.

ACTIVE ISOLATION

79-2062

The Potential for Active Suspension Systems

H.B. Sutton

Bolton Inst. of Technology, Auto. Engr. (UK), 4 (2), pp 21-24 (Apr/May 1979) 5 figs, 44 refs

Key Words: Suspension systems (vehicles), Active isolation

The limitations of passive suspensions are discussed and compared with the potential advantages of active suspensions. Approaches to suspension design in recent years and new mathematical procedures that can be applied are also outlined.

AIRCRAFT

(Also see Nos. 1964, 1969, 1971)

79-2063

Tests of Crash-Resistant Fuel System for General Aviation Aircraft

W.M. Perrella, Jr.

National Aviation Facilities Experimental Ctr., Atlantic City, NJ, Rept. No. FAA-NA-78-48, FAA/RD-78-122, 38 pp (Dec 1978)
AD-A063 816/3GA

Key Words: Aircraft, Fuel tanks, Crashworthiness

Testing was performed to demonstrate the performance of lightweight, flexible, crash-resistant fuel cells combined with the use of frangible fuel line couplings. Included in these tests were four full-scale crash tests of a typical light twin aircraft.

79-2064

Flutter Suppressor for Transonic Flight

R. Destuynder

European Space Agency, Paris, France, In: its La Rech. Aerospatiale, Bi-monthly Bull. No. 1978-3 (ESA-TT-522), pp 46-64 (Dec 1979) (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel, No. 1978-3, pp 117-123 (May-June 1978))
N79-20983

Key Words: Aircraft, Vibration control, Flutter

A dynamically similar model of the half-wing of a modern aircraft was equipped with a weighted external tank in order to obtain flutter at transonic velocity. Flutter control is achieved by a classical aileron that produces a reduction in frequency of the lowest flutter mode through the effect of negative stiffness. Different values of the feedback phase were employed in order to determine the stability range as a function of feedback phase.

79-2065

Dipole Modeling and Nondimensionalization of Airframe Noise

A.B. Bauer

Douglas Aircraft Co., Long Beach, CA, J. Aircraft, 16 (6), pp 398-400 (June 1979) 1 fig, 2 tables, 11 refs

Key Words: Aircraft noise, Mathematical models

Examples of the coefficients are given for various flight and configuration conditions for both the DC-9-31 and the DC-10-10 aircraft. A significant body of airframe noise data has been published and is available for conversion to non-dimensional form, both for the representation of overall sound pressure levels and for any one or more one-third octave band levels.

79-2066

Effectiveness of Aircraft Takeoff Procedures for Noise Abatement

W.C. Sperry

U.S. Environmental Protection Agency, Washington, D.C., Noise Control Engr., 12 (3), pp 116-130 (May/June 1979) 9 figs, 22 refs

Key Words: Aircraft noise, Noise reduction

Thirty-six airplane departures, consisting of two weights for each of three types of aircraft executing six takeoff procedures are evaluated for noise abatement effectiveness. The evaluation is based upon comparisons of noise levels on the ground and population highly annoyed.

79-2067

A Method for Calculating Longitudinal Characteristics of Wings and Multiple Lifting Surfaces in Subsonic Flow, and at High Angles of Attack

D. Almosnino, C. Zorea, and J. Rom

Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, Israel J. Tech., 16 (3), pp 132-141 (1978) 15 figs, 15 refs

Key Words: Aircraft wings, Aerodynamic excitation, Vortex-induced excitation

This paper presents a method for the calculation of the non-linear, longitudinal aerodynamic characteristics of various planar shapes including multiple lifting surface configurations in subsonic flow at high angles of attack. The method developed can handle complex planforms such as closely coupled canard-wing combinations, wing-tail combinations, various flaps, elevators, dihedral angles as well as ground effect problems. The present work uses a modification of the known Vortex Lattice Method, by including the effects of the shedding and of the development of the rolled-up wake. The results of the calculations for wings of various shapes and for closely coupled canard-wing configurations are compared with experimental data.

79-2068
Some Observations on the Mechanism of Aircraft Wing Rock
C. Hwang and W.S. Pi
Northrop Corp., Hawthorne, CA, J. Aircraft, 16 (6), pp 366-373 (June 1979) 14 figs, 6 refs

Key Words: Aircraft wings, Model testing

A scale model of the Northrop F-5A was tested in NASA Ames Research Center Eleven-Foot Transonic Tunnel to simulate the wing rock oscillations in a transonic maneuver. For this purpose, a flexible model support device was designed and fabricated, which allowed the model to oscillate in roll at the scaled wing rock frequency. Two tunnel entries were performed to acquire the pressure (steady state and fluctuating) and response data when the model was held fixed and when it was excited by flow to oscillate in roll.

79-2069
Vortex-Induced Asymmetric Loads on Slender Vehicles
L.E. Ericsson and J.P. Reding
Lockheed Missiles and Space Co., Inc., Sunnyvale, CA, Rept. No. LMSC-D630807, 237 pp (Jan 1979) AD-A065 012/7GA

Key Words: Aircraft vibration, Vortex-induced vibration

The steady and unsteady vortex-induced asymmetric loads on slender vehicles are investigated. The study reviews pertinent two- and three-dimensional data; develops analytic means for predicting the upper limit for vortex-induced asymmetric loads; and assesses the importance of these loads to the vehicle dynamics of slender bodies of revolution.

79-2070
Nonlinear Hypersonic Viscous Crossflow Effects on Slender Vehicle Dynamics
L.E. Ericsson
Lockheed Missiles and Space Co., Inc., Sunnyvale, CA, AIAA J., 17 (6), pp 586-593 (June 1979) 8 figs, 26 refs

Key Words: Fluid-induced excitation, Flight vehicles

The nonlinear hypersonic viscous crossflow effects on slender vehicle dynamics are described.

79-2071
Effects of Wind on Aircraft Cruise Performance
F.J. Hale and A.R. Steiger
North Carolina State Univ., Raleigh, NC, J. Aircraft, 16 (6), pp 382-387 (June 1979) 7 figs, 7 refs

Key Words: Aircraft, Wind-induced excitation

Analytic expressions are developed that predict the improvements in range, flight time, and fuel consumption that can be achieved by appropriate corrections to the no-wind best-range airspeed. Input data required are type of power plant, no-wind best-range airspeed, and magnitude of the headwind or tailwind component.

BUILDING

(Also see No. 2084)

79-2072
A Measuring Procedure for Determining Structure-Borne Sound and its Transmission (Ein Messverfahren zur Bestimmung von Körperschallanregung und -übertragung)
K.-J. Buhlert and J. Feldmann
Institut f. Technische Akustik der Technischen Universität Berlin, Acustica, 42 (2), pp 108-113 (Apr 1979) 6 figs, 3 refs
(In German)

Key Words: Buildings, Noise measurement, Vibration measurement

A procedure has been developed for measuring the structure-borne sound sensitivity of building structures. The method permits the measurement of the vibratory point forces due to structure-borne sound sources in buildings. A measurement parameter is defined and data is collected for several different types of building construction. Many measurements are made of forces resulting from installed equipment and technical appliances in buildings. The precision and reproducibility of the measurement procedure are tested.

79-2073
A Model Investigation of the Acoustical Performance of Courtyard Houses with Respect to Noise from Road Traffic
D.J. Oldham and E.A. Mohsen

Dept. of Bldg. Science, Univ. of Sheffield, Sheffield, UK, Appl. Acoust., 12 (3), pp 215-230 (May 1979) 9 figs, 1 table, 8 refs

Key Words: Buildings, Noise measurement, Traffic noise, Model testing, Computerized simulation

The action of courtyard houses in reducing the noise nuisance from road traffic is examined using the techniques of computer simulation and acoustic scale modeling.

79-2074

Airborne and Impact Noise Level Criteria for Buildings

G.L. Fuchs and N. Stasyszyn

Centro de Investigaciones Acusticas, Ciudad Universitaria, Est 32, 5000 Cordoba, Argentina, Appl. Acoust., 12 (3), pp 187-194 (May 1979) 5 figs, 4 refs

Key Words: Buildings, Noise reduction

A new criteria for the control of airborne and impact noises in buildings are proposed.

79-2075

Variation of the Outdoor Noise Level and the Sound Attenuation of Windows with Elevation Above the Ground

T.J. Schultz

Bolt Beranek & Newman, Inc., 50 Moulton St., Cambridge, MA 02138, Appl. Acoust., 12 (3), pp 231-239 (May 1979) 8 figs, 10 refs

Key Words: Buildings, Noise reduction

This paper deals with an attempt to cope with the problem of providing suitably quiet dwellings in noisy urban environments. It has sometimes been suggested that the lower floors of high-rise buildings might be used for offices (or other noise-insensitive uses), while the upper, presumably quieter, floors could be used for housing.

79-2076

Wind Excited Motion of Buildings

A. Kareem

Ph.D. Thesis, Colorado State Univ., 338 pp (1978) UM 7913820

Key Words: Buildings, Wind-induced excitation

The complex nature of wake-excited crosswind response is investigated in this study. A wind tunnel study of a square cross-section building model immersed in thick turbulent boundary layers simulating two typical neutral atmospheric flow conditions is undertaken in order to determine the fluctuating crosswind force and the effects of incident flow properties on the fluctuating pressure field acting on the model. Measurements are made that enable computation of the mean and rms pressure coefficients, power spectral density functions, autocorrelations, cross-spectral density functions, cross-correlations, orthogonal eigenfunction expansions, probability and joint probability histograms of the fluctuating pressure on the side faces of the building model.

FOUNDATIONS AND EARTH

79-2077

Spring Stiffness and Damping Coefficients for Viscoelastic Foundations with Strip-Shaped Base Pressure (Federsteifigkeiten und Dämpfungskoeffizienten f. viskoelastische Gründungen mit streifenförmiger Sohldruckverteilung)

W. Knobloch

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 211-217, 12 figs, 5 refs

(In German)

Key Words: Stiffness coefficients, Damping coefficients, Viscoelastic foundations, Mathematical models

A calculation method for the dynamic stress boundary value problem of a viscoelastic half space is described, from which simulation of parameters (spring stiffness and damping coefficients) for structural foundations may be obtained. The base pressure is presented in constant deflection strips.

79-2078

Coupled Structure-Foundation Vibrations (Koppelschwingungen einer Struktur auf dem Baugrund)

L. Gaul
Schwingungen von Maschinen und Bauwerken. Modellfindung. Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 219-224, 8 figs, 4 refs
(In German)

Key Words: Interaction: structure-foundation, Coupled response, Mathematical models

Foundation-structure interaction is formulated as a mixed boundary value problem of the elastic foundation. The method produces elastic restoring forces, inertia forces, and the damping effects of the infinite halfspace (foundation) in a dynamic stiffness matrix, which is coupled with a mathematical model of the structure. Spatial motions of a structure on a desired foundation may be calculated by the use of an experimentally derived viscoelastic material model of the foundation.

79-2079
Determination of Dynamic Characteristics of Machine Foundations (Ermittlung der dynamischen Bodenkennwerte f. Maschinengrundungen)
W. Haupt
Schwingungen von Maschinen und Bauwerken. Modellfindung. Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 225-232, 6 figs, 20 refs
(In German)

Key Words: Machine foundations, Vibration measurement, Viscoelastic foundations, Seismic response, Resonant bar technique

Calculation of dynamically loaded foundations and the effect of viscoelastic foundation parameters is presented. Methods for the measurement of these parameters in the field and the laboratory are described.

79-2080
Geophysical Studies for Missile Basing. Seismic Risk Studies in the Western United States
J.C. Battis
Equipment Group, Texas Instruments, Inc., Dallas, TX, Rept. No. TI-ALEX(02)-FSR-78-01, AFOSR-TR-79-0038, 92 pp (Dec 20, 1978)
AD-A064 798/2GA

Key Words: Missile silos, Seismic excitation, Earthquake resistant structures

Seismic risk studies were conducted for two military facilities in the western United States: Luke Air Force Base, Arizona, and the Nevada Test Site (NTS). Both facilities are potential sites for MX missile system installations. For each site, peak around motion risk curves, for annual risks ranging between values of 1.0 and 0.001, were estimated, based on seismicity characteristics of the risk regions surrounding each facility.

HELICOPTERS
(Also see Nos. 1997, 2085, 2106, 2111)

79-2081
Model Verification of Force Determination for Measuring Vibratory Loads
F.D. Bartlett, Jr. and W.G. Flannelly
Structures Lab., U.S. Army Res. and Tech. Labs., (AVRADCOM), NASA Langley Research Center, Hampton, VA, J. Amer. Helicopter Soc., 24 (2), pp 10-18 (Apr 1979) 3 figs, 9 tables, 11 refs

Key Words: Helicopter vibration, Vibration measurement, Mathematical models

Force determination is a multiple regression technique for determining vibratory forces and moments using response measurements and dynamic calibration data. The response measurements are distributed throughout the structure and the calibration data are the partial derivatives of the response to each external force or moment. The method was verified with laboratory tests to determine vibratory hub forces on a helicopter dynamic model. The hub calibration data were obtained from both direct hub shaking and single-point shaking at the nose of the dynamic model. Vertical and lateral forces were simultaneously applied to the hub of the dynamic model with electromagnetic shakers.

79-2082
A New Analytic Method for the Study of Classic Helicopter Ground Resonance
H.L. Price
Univ. of Leeds, UK, Israel J. Tech., 16 (3), pp 142-153 (1978) 13 figs, 9 refs

Key Words: Helicopters, Dynamic response, Resonant frequency

A new analytic method for the study of classic helicopter ground resonance is described.

ISOLATION

79-2083
From Hydroelastic to Hydragas Suspension
A.E. Moulton and A. Best
Moulton Developments Ltd., Bradford-on-Avon, Wiltshire, Instn. Mech. Engr. Proc., 193, pp 15-37 (Mar 1979) 40 figs, 7 refs

Key Words: Suspension systems (vehicles), Ride dynamics

The paper reviews the development of the fluid interconnected Hydroelastic and Hydragas suspension systems, and follows with a description and explanation of their principles. Comparisons are made of ride performance between these systems and the conventional suspension by both measurement and mathematical predictions. Comparisons of cost and weight for various installations are also shown.

79-2084
Isolation System Reduces Transmission of Vibration
Des. News., 35 (10), p 36 (May 21, 1979) 3 figs

Key Words: Isolators, Vibration isolators, Buildings, Vibration control, Noise reduction

To achieve the highest degree of control of structure-borne vibration and noise in buildings excited by mechanical equipment, the ratio of the operating speed to the natural frequency of isolators should be above 1.4. In addition, vibration isolators must be selected to compensate for the floor deflection. A selection guide is presented for the evaluation of these parameters.

79-2085
Helicopter Flight and Laboratory Vibration Tests for Flight Demonstration Model of Airspring Vibration Isolator
T.N. Lee
Huntsville Electronics Div., Chrysler Corp., Huntsville, AL, Rept. No. HMS-R02-78, 112 pp (Jan 30, 1978)
AD-A-064 342/9GA

Key Words: Isolators, Vibration isolators, Rotor-induced vibration, Helicopter rotors, Vibration tests

An isolation system designated as Airspring Vibration Isolator (AVI) was developed to isolate the rotor-induced vibration from transmitting to the launcher-missile system. A ground demonstration model of the AVI was designed and manufactured at MIRADCOM. Chrysler designed and manufactured a flight demonstration model of the AVI. The laboratory vibration tests of the AVI flight demonstration model include a vertical vibration test, transverse vibration test and longitudinal vibration test with base excitations along the three principal axes, respectively. Each vibration test in turn includes a sweep-sine test, random test and shock test.

MATERIAL HANDLING

79-2086
Effect of Design Parameters on the Operational Properties of the Conveyor (Einfluss konstruktiver Parameter auf die Betriebseigenschaften der Fördermittel)
H.J. Roos
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 149-157, 13 figs, 1 table, 12 refs
(In German)

Key Words: Conveyors, Material handling systems, Design techniques

The article discusses dynamic properties of spatial steel frameworks, system-correlated engine groups, and calculation of the motion of reduced dynamic systems.

MECHANICAL

79-2087
Mechanical and Structural Vibrations. Modeling, Calculation and Measurement

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung., VDI Berichte 320, VDI Verlag GmbH, Düsseldorf 1978 (In German)

Key Words: Vibration response, Rotors (machine elements), Transportation vehicles, Earthquake response, Machinery vibration, Machine drives, Machine tools, Proceedings

The volume contains the papers presented at the VDI Vibration Conference held October 12-13, 1978 in Karlsruhe, Germany. The Conference consisted of four major topics: rotordynamics, vibrations in conveyor and transportation vehicles, earthquake excited vibrations, and drive and machine tool vibrations. The individual papers present the personal views of the authors. They are abstracted in this issue of the DIGEST.

79-2088

Hydrostatic Equipment Noise Reduction (Zur Gerauschminderung an hydrostatischen Anlagen)

U. Jensen
Fachgebiet Landmaschinen und Olhydraulik am Institut f. Maschinenkonstruktion der TU Berlin,
Konstruktion, 30 (4), pp 129-136 (Apr 1978) 17 figs, 24 refs
(In German)

Key Words: Noise reduction, Equipment response, Hydrostatic excitation

The basics of current technology and economics of noise reduction in hydrostatic equipment is presented. After a brief introduction to the principles of noise generation and control, the authors discuss primary measures to be taken with the most critical noise exciters – the displacement machinery, as well as means for reducing noise in valve and piping systems.

METAL WORKING AND FORMING

79-2089

Criteria for the Optimum Design of Feed Drives for Copying and Numerical Control Machine Tools (Kriterien der optimalen Auslegung von Vorschubantrieben f. Nachform- und numerisch gesteuerte Werkzeugmaschinen)

H. Arafa
Mechanical Design and Production Engrg. Dept., Faculty of Engrg., Cairo Univ.,
Konstruktion, 31 (3), pp 97-105 (Mar 1979) 13 figs, 1 table, 10 refs
(In German)

Key Words: Optimum design, Machine tools

Necessary criteria for the optimum design of feed drives, taking into account their dynamic behavior are presented. Besides the acceleration capacity and its relation to the reduced load capacity, the sensitivity toward the changes of the machine as well as the distribution of the kinetic energy in the system are included.

79-2090

Model Development for the Calculation of Vibration During Broaching (Modellbildung zur Berechnung der Schwingungsvorgänge beim Innenräumen)

J. Wauer
Schwingungen von Maschinen und Bauwerken. Modellfindung. Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 241-248, 8 figs, 4 refs
(In German)

Key Words: Mathematical models, Machine tools

A physical model of a nonlinear boundary value problem, using Hamilton's Principle, is developed for the description of tensile and flexural vibrations of a scraping pin. The integrodifferential equation with its boundary and transfer conditions is reduced to a set of usual differential equations for time behavior.

79-2091

Measures for Improving the Dynamic Behavior of Spinning Machine Tools (Massnahmen zur Verbesserung des dynamischen Verhaltens spanender Werkzeugmaschinen)

M. Weck and K. Teipel
Schwingungen von Maschinen und Bauwerken. Modellfindung. Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag, GmbH - Düsseldorf 1978, pp 233-240, 12 figs, 3 refs
(In German)

Key Words: Machine tools, Chatter, Vibration control

The basic problems of spinning machine tool dynamics, e.g., the relative motions in the guideways, are discussed and design changes for improving dynamic stability of the system are given.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see Nos. 1978, 2107)

79-2092

Theory of Low Frequency Noise Transmission Through Turbines

R.K. Matta and R. Mani

Aircraft Engine Group, General Electric Co., Evendale, OH, Rept. No. NASA-CR-159457; R77AEG-570, 153 pp (Mar 1979)

N79-20117

Key Words: Turbines, Noise transmission, Computer programs

Improvements of the existing theory of low frequency noise transmission through turbines and development of a working prediction tool are described. The existing actuator-disk model and a new finite-chord model were utilized in an analytical study. The interactive effect of adjacent blade rows, higher order spinning modes, blade-passage shocks, and duct area variations were considered separately. The improved theory was validated using the data acquired in an earlier NASA program. Computer programs incorporating the improved theory were produced for transmission loss prediction purposes. The programs were exercised parametrically and charts constructed to define approximately the low frequency noise transfer through turbines. The loss through the exhaust nozzle and flow(s) was also considered.

79-2093

Vibration and Noise of Large Turbomachinery

R.L. Bannister

Westinghouse Electric Corp., Philadelphia, PA, S/V, Sound Vib., 13 (4), pp 14-21 (Apr 1979) 16 figs, 47 refs

Key Words: Turbomachinery, Electric power plants, Steam turbines, Vibration generation, Noise generation, Diagnostic techniques

Vibration and noise of large turbomachinery, such as central-power-station steam and gas turbines, are reviewed. The major emphasis is on steam turbines. A brief look into diagnostic techniques is given.

RAIL

(Also see Nos. 1913, 1914, 1915)

79-2094

Dynamic Analysis to Establish Normal Shock and Vibration of Radioactive Material Shipping Packages

S.R. Fields and S.J. Mech

Hanford Engineering Development Lab., Richland, WA, Rept. No. HEDL-TME-78-102, NUREG-CR-0589, 43 pp (Mar 1979)

PB-293 660/7GA

Key Words: Shipping containers, Radioactive materials, Railroad cars, Impact shock

A new calculation sequence is developed to simulate the behavior of the coupler subsystem for the cask-rail car (hammer car) and the lead car in the group it impacts (struck car) during humping operations. This new coupler submodel simulates the hysteresis-type behavior of friction draft gears. Friction draft gears consist of springs and dampers in parallel.

79-2095

Elastic and Inelastic Deformation Response of Track Structures Under Train Loads

C. Adegoke-Anthony

Ph.D. Thesis, State Univ. of New York at Buffalo, 263 pp (1979)

UM 7913854

Key Words: Railroad (tracks), Mathematical models

In this study, the adequacy of the current state-of-the-art methods of predicting track response is given a critical appraisal. Based on a survey of recently developed analytical models for track support systems, three computer models which are considered to have the potential of representing reasonably the various components of the track system are chosen for critical evaluation and validation. The models are MULTA, PSA, and ILLITRACK. The models are studied and their predictions are compared with measurements obtained from a full-scale experimental field test, FAST (Facility for Accelerated Service Testing), Pueblo, Colorado.

79-2096

Noise Assessment of the Chicago Transit Authority Rail Rapid Transit System

M.L. Silver, R.C. Buchus, and R. Priemer

Illinois Univ at Chicago Circle, IL, Rept. No. UMTA-MA-06-0025-79-8, DOT-TSC-UMTA-78-52, 305 pp (Jan 1979)

Key Words: Rapid transit railways, Transportation systems, Noise generation

The report describes the noise on and near the Chicago Transit Authority (CTA) urban rail transit lines. Noise data are given for specific measurements made in cars, in stations, and along the non-subway wayside at selected locations. The rationale for choice of measurement sites and the methodology for arriving at the summary noise distributions from the data is discussed. Measurement and analysis instrumentation and procedures are also described.

79-2097

Some Aspects of Noise From British Passenger Trains

C.J. Baker, A.C. Salvidge, and W.A. Utley

Bldg. Research Station, Garston, Watford WD2 7JR, UK, J. Sound Vib., 64 (4), pp 589-596 (June 22, 1979) 4 figs, 6 refs

Key Words: Railroad trains, Traffic noise, Noise measurement

Measurements of noise from British passenger trains obtained at two urban sites are reported. Noise time histories of trains containing coaches which produce different individual noise levels have been predicted and are compared with measured time histories. The measurements of peak noise level are compared with three current prediction curves.

79-2098

Noise Assessment of the New York City Rail Rapid Transit System

W.R. McShane, S. Slutsky, and M.F. Huss

Dept. of Transportation Planning and Engrg., Polytechnic Inst. of New York, Brooklyn, NY, Rept. No. DOT-TSC-UMTA-78-53, UMTA-MA-06-0025-79-7, 359 pp (Jan 1979)

PB-292 498/3GA

Key Words: Rail transportation, Rapid transit railways, Noise reduction

The report describes the noise climate on and near the New York City Transit Authority (NYCTA) urban rail system, including the Staten Island Rapid Transit Operating Authority (SIRTOA). Noise level data is also presented for the Port Authority Trans-Hudson (PATH) urban rail system. Noise level data are given for specific measurements made in cars, stations and along the above ground wayside at approximate locations. The rationale for choice of measurement sites and the methodology for arriving at the summary noise distributions from the data is discussed explicitly. Measurement and analysis instrumentation and procedures are also described.

79-2099

Noise Abatement in Rail Rapid Transit: Effect of Some Variations

W.R. McShane and S. Slutsky

Dept. of Transportation Planning and Engrg., Polytechnic Inst. of New York, Brooklyn, NY, Rept. No. UMTA-NY-11-0002-79-1, 163 pp (Dec 1978)

PB-292 032/0GA

Key Words: Railroad trains, Rail transportation, Rapid transit railways, Noise reduction

In this report the abatement methodology is refined and a number of case studies conducted. This report focuses on changes in the system-wide treatment plan, the program cost, and the net impact due to such factors as: variations in discount rate; changes in abatement target level; introduction of new cars; prohibition of certain treatments, such as resilient wheels and steel barriers; and specification of certain treatments on a categoric basis.

79-2100

Noise Degradation Over Time in Rail Rapid Transit Cars

S. Slutsky, W.R. McShane, and J.J. Starace

Polytechnic Inst. of New York, Brooklyn, NY, Rept. No. UMTA-NY-11-0002-79-2, 69 pp (Dec 1978)

PB-292 031/2GA

Key Words: Railroad trains, Rail transportation, Rapid transit railways, Noise reduction

The purpose of this effort is to study the degradation of noise quality of selected cars over time, and to relate this

degradation to treatment events. Three trains were observed monthly for a period of seven months in an extensive collection and analysis effort.

RECIPROCATING MACHINE

79-2101
Wind-Tunnel Shock-Tube Simulation and Evaluation of Blast Effects on an Engine Inlet
J.R. Ruetenik and R.F. Smiley
Kaman AviDyne, Burlington, MA, Rept. No. KA-TR-147, DNA-4590F, AD-E300 451, 240 pp (Mar 15, 1978)
AD-A065 388/1GA

Key Words: Aircraft engines, Blast effects, Nuclear explosion effects, Shock tube tests

This report describes a program for simulating blast wave intercepts with a scaled aircraft engine in subsonic flight, using the shock tube technique for firing the blast-type waves. The model inlets were instrumented with 40 combination steady-state and dynamic total-pressure probes at each engine face section and other dynamic transducers to measure incident blast wave properties and inlet internal ramp and cowl pressures.

ROAD
(Also see No. 1916)

79-2102
Vibration and Stability Problems of Magnetic Suspension Vehicles and Their Interaction with Elastic Roadways (Schwingungs- und Stabilitätsprobleme von Magnetschwebe-Fahrzeugen bei Wechselwirkung mit elastichen Fahrwegen)
O. Wallrapp
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 109-115, 5 figs, 3 tables, 7 refs
(In German)

Key Words: Interaction: vehicle-guideway, Ground effect machines, Stability

Modeling of vehicle elasticity is presented and the computation of the required vehicle degrees of freedom is given. Stability behavior of vehicle and roadway during stationary suspension is discussed and demonstrated by means of an example.

79-2103
Nonlinear Vehicle Dynamics Demonstrated by Means of an Articulated Vehicle (Nichtlineare Fahrzeugdynamik dargestellt am Beispiel Sattelschlepper)
J. Wittenburg
Schwingungen von Maschinen und Bauwerken. Modellfindung. Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 117-122, 4 figs, 1 ref
(In German)

Key Words: Nonlinear theories, Articulated vehicles, Mathematical models

By means of a mathematical model of an articulated vehicle, the exact nonlinear differential equations are developed which describe every rigid body system having a tree structure. The equations can be programmed in a general form, without the knowledge of the number of masses, the distribution and kinematic properties of the linkages, the type of external and internal forces, and other system parameters. This information is given for each individual case on data cards and in simple subroutines.

79-2104
Analysis of Rigid Pavement on Viscoelastic Foundation Subjected to Moving Loads
S.S. Bandyopadhyay
Ph.D. Thesis, Oklahoma State Univ., 78 pp (1978)
UM 7912610

Key Words: Roads (pavements), Pavements, Viscoelastic foundations, Moving loads

The dynamic behavior of road structure is analyzed by idealizing the subgrade with different viscoelastic models having three and four elements. Complex Fourier transformation is used to solve the resulting differential equations. All the parameters are nondimensionalized. The results are presented in nondimensional form. A detailed study is made to determine the effect of different parameters, namely, the velocity ratio of the moving load, and elastic and viscous constants of the foundation, on the deflection and moment of the pavement. The relative implica-

tion of idealizing the subgrade with different viscoelastic models is studied.

79-2105

The TRRL Quiet Heavy Vehicle Project

J.W. Tyler

Transport and Road Res. Lab., Crowthorne, Berkshire, Instn. Mech. Engr. Proc., 193, pp 137-147 (Mar 1979) 14 figs, 7 tables, 7 refs

Key Words: Traffic noise, Ground vehicles, Articulated vehicles, Noise reduction, Regulations

This paper describes a cooperative program which has produced heavy diesel engined articulated vehicles having considerably lower external and internal noise levels than vehicles in current operation. The work was directed at reducing the noise levels from the engine, exhaust and cooling systems, tire-road surface interaction, and the transmission of noise into the cab. The environmental background to the project and its relation to future legislation on vehicle noise is considered as well as the bases for the technical solutions evolved.

ROTORS

(Also see Nos. 1950, 1951, 1952, 1955, 1956, 1959)

79-2106

Flap-Lag-Torsion Aeroelastic Stability of Circulation-Controlled Rotors in Hover

I. Chopra and W. Johnson

NASA Ames Research Ctr., Moffet Field, CA, J. Amer. Helicopter Soc., 24 (2), pp 37-46 (Apr 1979) 19 figs, 5 refs

Key Words: Stability, Rotors, Blades, Helicopters, Aeroelasticity

The results of a theoretical investigation of the flap-lag-torsion stability of circulation-controlled rotors in hover are presented. Stability boundaries are presented as a function of thrust and lag frequency. The effects of several parameters on the blade flap-lag stability are examined, including structural damping, structural coupling, pitch-lag and pitch-flap coupling, and the blade feathering motion. The implications of these results for the current CCR and X-Wing rotorcraft designs are considered.

79-2107

Operating Stability of Simple Turborotors, Especially in the Presence of Excessive Clearance (Zur Laufstabilitat einfacher Turborotoren, besonders bei Spalterregung)

H.-J. Thomas

Institut f. thermische Kraftanlagen mit Heizkraftwerk der TU München, Munich, Germany, Konstruktion, 30 (9), pp 339-344 (Sept 1978) 11 figs, 18 refs (In German)

Key Words: Rotors (machine elements), Turbines, Clearance effects, Stability

Causes of self-excited rotor vibrations in thermal turbomachinery are discussed. The excitation is derived from the clearance loss and pressure distribution in radial seals. Differential equations of motion are set up for a simple rotor model and its stability is determined. The effect of various system parameters, particularly that of the bearings, on the stability is illustrated using the turbine as an example. The drawbacks of the application are also included.

79-2108

Changes in the Vibratory Behavior of Shafts in Friction Bearings Caused by Supplemental Effects (Veränderungen im Schwingungsverhalten gleitgelagerter Wellen infolge von Zusatzeinflüssen)

J. Glienicke

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 1-8, 12 figs, 6 refs (In German)

Key Words: Shafts (machine elements), Rotor-bearing systems, Friction bearings

The rotor disturbances discussed in the article are gyroscopic couple and the effects of supplemental static loads. Bearing effects are turbulence, lubricating film inertia forces, and oil feed. The effects of bearing shell supports and foundation effects comprise the disturbances which originate in the substructure.

79-2109

Experimental Determination of Modal Values of Rotors (Experimentelle Ermittlung modaler Grössen von Rotoren)

R. Nordmann and K. Schöllhorn
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung, Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 15-24, 9 figs, 5 refs (In German)

Key Words: Rotors (machine elements), Modal tests, Testing techniques

An experimental technique for the determination of modal values (eigenvalues and natural mode shapes) of rotor-friction bearing systems is described. The method is illustrated on a simple rotor test stand (Laval shaft). It can also be used for larger turborotors under similar excitation.

79-2110

Design of Rotor-Bearing Systems Required to Pass Through a Number of Critical Speeds (Zur Auslegung mehrfach überkritischer Rotore und deren Lagerung)

H. Heckel and P. Meinke
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung, Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 25-29, 6 figs, 7 refs (In German)

Key Words: Rotors (machine elements), Critical speeds, Design techniques

The design of rotors with flexible couplings in damped multimass bearings is described.

79-2111

Observations on the Dynamic Stall Characteristics of Advanced Helicopter Rotor Airfoils

L. Dadone
Boeing Vertol Co., Philadelphia, PA, In: NASA Langley Res. Ctr. Advanced Tech. Airfoil Res., Vol. 1, Pt. 2, pp 701-715 (1978)
N79-20006

Key Words: Helicopter rotors, Vibration tests

This paper summarizes the results of several oscillatory tests carried out on conventional, transonic and BLC-equipped airfoils.

79-2112

Flap-Lag-Torsion Flutter Analysis of a Constant Life Rotor

I. Chopra
Joint Inst. for Aeronautics and Acoustics, Stanford Univ., CA, Rept. No. NASA-CR-152244; SU-JIAA-TR-17, 42 pp (Jan 1979)
N79-20099

Key Words: Rotors, Flutter

A flap-lag-torsion flutter analysis of a constant lift rotor blade in hover is developed. The blade model assumes rigid body flap and lead-lag motions at the root hinge and each strip undergoes an independent torsional motion. The results are presented in terms of root locus plots of complex eigenvalues as a function of thrust. The effects of several parameters (including structural damping, center of gravity and elastic axis offset from aerodynamic center, compressibility pitch-lag and pitch-flap coupling) on the blade dynamics are examined.

79-2113

The Role of Rotor Impedance in the Vibration Analysis of Rotorcraft, Part 4. Final Report

K.H. Hohenemser
School of Engrg. and Appl. Science, Washington Univ., St. Louis, MO, Rept. No. NASA-CR-152261, 38 pp (June 1978)
N79-20103

Key Words: Rotors, Blades, Mechanical impedance, Vibration response

A method for a strongly idealized case of vertical excitation and for rolling and pitching moment excitation of a four bladed hingeless rotor on an up-focussing flexible mount is developed. The aeroelastic rotor impedances are computed directly with a finite blade element method that includes aerodynamics. The rotor impedance matrix for three or more blades is determined from the root moment impedance for a single blade by a simple multiblade transformation rule.

79-2114

Unbalance Vibrations and System Damping of Rotors in Sliding Bearings under Conditions Approximating Operational Conditions (Unwuchtschwingungen und Systemdampfung gleitgelagerter Rotoren unter praxisnahen Bedingungen)

J. Glienicke and R. Wiedenmann
Institut f. Maschinenkonstruktionslehre der Universitat Karlsruhe (TH), Konstruktion, 30 (8), pp 311-317 (Aug 1978) 13 figs, 10 refs
(In German)

Key Words: Rotor-bearing systems, Sliding bearings

Numerous experimental investigations are described which show that several additional effects will significantly affect the vibration of rotors in sliding bearings. The additional effects are: large bearing pressures under high peripheral velocities, support of bearing shell including the elasticity of bearing block, static bearing swing, the inertia forces of lubricant fluids and turbulent lubricant leakage flow, as well as oil feed.

79-2115
Turborotor Vibrations (Schwingungen von Turborotoren)
R. Nordmann
Wissenschaftlicher Mitarbeiter am Fachgebiet Maschinendynamik der TH Darmstadt, Konstruktion, 30 (9), pp 345-351 (Sept 1978) 14 figs, 16 refs
(In German)

Key Words: Rotors (machine elements), Turbomachinery, Flexural vibration, Self excited vibrations, Transient response, Unbalanced mass response

In the article flexural vibrations of large turbomachinery rotors are discussed. These vibrations are subdivided into natural vibrations (including the self-excited vibrations), unbalance excited vibrations and transient vibrations. Forces acting on the system, as well as the equations of motion and method for the calculation of vibrations are given.

SELF-EXCITED

79-2116
Self-Excited Vibrations in Multiroller Structures. Causes and Remedies (Selbsterregte Schwingungen in Mehrwalzengerüsten. Ursache und Abhilfemassnahmen)
A.H. Glattfelder, A. Christ, L. Huser, and G. Boos
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 143-147, 6 figs, 7 refs
(In German)

Key Words: Self-excited vibrations, Machinery

Higher working speeds of glazing machinery in the paper industry cause strong vibrations, leaving undesirable markings on the paper, called barring. Stability of such machinery is investigated and measures for the prevention of barring are given.

SHIP

79-2117
The Diffraction Forces for a Ship Moving in Oblique Seas
A.W. Troesch
Dept. of Naval Architecture and Marine Engrg., The Univ. of Michigan, Ann Arbor, MI, J. Ship Res., 23 (2), pp 127-139 (June 1979) 10 figs, 1 table, 17 refs

Key Words: Ships, Water waves

The diffraction problem of a fixed slender ship moving in incident waves is formulated. The waves are assumed to be of the same order as the beam of the ship and are from an oblique heading. The boundary-value problem is linearized with respect to wave amplitude and solved by the method of matched asymptotic expansions. The oscillating forward-speed potential is solved to two orders of magnitude.

79-2118
A Scheme for the Interpretation of Data from Instrumented Offshore Platforms
P.E. Duncan
Dept. of Mech. Engrg., Univ. College London, WC1E 7JE, UK, J. Sound Vib., 64 (4), pp 497-513 (June 22, 1979) 10 figs, 20 refs

Key Words: Off-shore structures, Interaction: soil-structure, Interaction: structure-fluid, Component mode synthesis, Parameter identification technique

A procedure is presented for estimating the key parameters associated with the dynamic behavior of deepwater gravity platforms. Efficient modeling of the coupled soil/structure/fluid system is achieved by the method of component modes. This permits accurate analysis of the dynamic behavior of the platform with an idealization having only a few coordinates. Full-scale measurements (in the form of direct and cross spectral densities of water surface elevation, overturning moment, deck displacement, etc.) may then be used to obtain best fit estimates of the unknown stiffness and damping parameters.

SPACECRAFT

79-2119

Propellant Grain Dynamics in Aft Attach Ring of Shuttle Solid Rocket Booster

V. Verderaime

NASA Marshall Space Flight Ctr., Huntsville, AL, Rept. No. NASA-TM-78220, 47 pp (Feb 1979)

N79-20263

Key Words: Shuttles (spacecraft), Solid rocket propellants, Rings

An analytical technique for implementing simultaneously the temperature, dynamic strain, real modulus, and frequency properties of solid propellant in an unsymmetrical vibrating ring mode is presented. All dynamic parameters and sources are defined for a free vibrating ring-grain structure with initial displacement and related to a forced vibrating system to determine the change in real modulus. Propellant test data application is discussed. The technique is developed to determine the aft attach ring stiffness of the shuttle booster at lift-off.

79-2120

A Generalized Modal Shock Spectra Method for Spacecraft Loads Analysis

M. Trubert and M. Salama

Jet Propulsion Lab., California Inst. of Technology, Pasadena, CA, Rept. No. NASA-CR-158417; JPL-Pub-79-2, 80 pp (Mar 1979)

N79-20177

Key Words: Spacecraft, Modal analysis, Shock response spectra

Generalization permits an accurate elastic interaction between the spacecraft and launch vehicle to obtain accurate bounds on the spacecraft response and structural loads. The modal response from a previous launch vehicle transient analysis with or without a dummy spacecraft is exploited to define a modal impulse as a simple idealization of the actual forcing function. The idealized modal forcing function is then used to derive explicit expressions for an estimate of the bound on the spacecraft structural response and forces.

79-2121

Studies of the Effects of Transitional and Turbulent Boundary Layers on the Aerodynamic Performance of Hypersonic Re-Entry Vehicles in High Reynolds Number Flows

M.S. Holden

Calspan Advanced Tech. Center, Buffalo, NY, Rept. No. CALSPAN-AB-5834-A-2, AFOSR-TR-79-0125, 326 pp (Dec 1978)

AD-A065 173/7GA

Key Words: Reentry vehicles, Aerodynamic characteristics

This report describes a series of studies to investigate the underlying aero-thermodynamic phenomena which influence the accuracy and survivability of Ballistic Reentry Vehicles. The influence of transition on the aerodynamic characteristics of slender RV's is discussed first. A detailed study is made of the influence of asymmetric nose bluntness on the pressure and heat transfer distribution over the cone frustum, and the contribution of the cone frustum to the forces and moments experienced by the total configuration.

STRUCTURAL

(Also see No. 2087)

79-2122

Natural Draft Cooling Tower Dynamics under Seismic Excitation. A Simple Approximation Model (Zur Dynamik von Naturzugkühltürmen unter seismischer Erregung: Ein einfaches Näherungsmodell)

K. Meskouris and W.B. Krätzig

Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Ver-

lag GmbH - Düsseldorf 1978, pp 187-193, 10 figs, 1 table, 11 refs
(In German)

Key Words: Cooling towers, Seismic excitation

A method is described for a fast and very detailed determination of cross-sectional forces and deformations of the shell and of the support structure of tall natural draft cooling towers.

TRANSMISSIONS

79-2123
Vibration of Gear Drives (Schwingungsverhalten von Zahnradgetrieben)
Ch. Troeder, H. Peeken, and G. Diekhans
Schwingungen von Maschinen und Bauwerken. Modellfindung, Berechnungsverfahren, Messung. Proc. Conf., Karlsruhe, 1978, VDI-Berichte 320, VDI Verlag GmbH - Düsseldorf 1978, pp 273-288, 16 figs, 1 table, 5 refs
(In German)

Key Words: Transmission systems, Gear drives, Vibration response, Shafts, Bearings

Vibration of multistep gear transmissions with multi-degrees of freedom is calculated, taking shaft deflection and radial and axial bearing flexibility into consideration. The same method can be applied for the calculation of gearing stiffness, shaft and wheel flexibility, and backlash.

TURBOMACHINERY

79-2124
Remarks on the Noise Emitted by a Turbomachine Jet
R. Legendre
European Space Agency, Paris, France, In: its La Rech. Aerospatial, Bi-monthly Bull. No. 1978-2 (ESA-TT-496), pp 1-14 (Nov 1978) (Engl. transl. from La Rech. Aerospatiale, Bull. Bimestriel, No. 1978-2, Mar/Apr 1978, pp 53-58)
N79-20975

Key Words: Turbomachinery, Noise generation

Three distinct noise sources are analyzed: turbulence, nonhomogeneity of temperature or entropy, and combustion. An equation is obtained in which the state variables are eliminated as far as possible.

AUTHOR INDEX

CALENDAR

NOVEMBER 1979

Product Liability [SEE - Society of Environmental Engineers] London, England *(Mrs. H.M.W. Gibbons, Owles Hall, Buntingford, Herts. SG9 9PL, UK - Tel - Royston 71209)*

4-6 Diesel and Gas Engine Power Technical Conference, San Antonio, TX *(ASME Hq.)*

5-8 Truck Meeting, [SAE] Marriott, Ft. Wayne, IN *(SAE Meeting Dept.)*

26-30 Acoustical Society of America, Fall Meeting, [ASA] Salt Lake City, UT *(ASA Hq.)*

27-29 8th Turbomachinery Symposium, [Gas Turbine Labs., Texas A&M University] Houston, TX *(Dr. M.P. Boyce, Gas Turbine Labs., Dept. of Mech. Engrg., Texas A&M University, College Station, TX 77843 - Tel (713) 845-7417)*

DECEMBER 1979

Aerospace Meeting [SAE] Los Angeles, CA *(SAE Meeting Dept.)*

2-7 Winter Annual Meeting [ASME] Statler Hilton, New York, NY *(ASME Hq.)*

JANUARY 1980

22-24 Reliability & Maintainability Symposium, San Francisco, CA *(ASME Hq.)*

FEBRUARY 1980

3-7 Energy Technology Conference and Exhibition [ASME] New Orleans, LA *(ASME Hq.)*

19 Current Techniques in Vibration Measurement and Recording [SEE] London, England *(SEE Hq.)*

26-29 Congress & Exposition [SAE] Cobo Hall, Detroit, MI *(SAE Meeting Dept.)*

MARCH 1980

9-13 25th Annual International Gas Turbine Conference and Exhibit [ASME] New Orleans, LA *(ASME Hq.)*

24-27 Design Engineering Conference and Show [ASME] McCormick Place, Chicago, IL *(ASME Hq.)*

APRIL 1980

21-25 Acoustical Society of America, Spring Meeting [ASA] Atlanta, GA *(ASA Hq.)*

MAY 1980

5-8 Offshore Technology Conference, Astrohall, Houston, TX *(ASME Hq.)*

19-23 Fourth International Conference on Pressure Vessel Technology [ASME] London, England *(ASME Hq.)*

25-30 Fourth SESA International Congress on Experimental Mechanics [SESA] The Copley Plaza, Boston, MA *(SESA Hq.)*

JUNE 1980

11 Experimental Techniques for Fatigue Crack Growth Measurement [SEE] British Rail Technical Centre *(SEE Hq.)*

17-19 International Conference on Vibrations in Rotating Machinery [ASME] Cambridge, England *(ASME Hq.)*

22-26 Summer Annual Meeting [ASME] Waldorf-Astoria, New York, NY *(ASME Hq.)*

JULY 1980

7-11 Recent Advances in Structural Dynamics Symp., [Institute of Sound and Vibration Research] University of Southampton, Southampton, S09 5NH, UK *(Mrs. O.G. Hyde, ISVR Conference Secretary, The University, Southampton, S09 5NH, UK - Tel (0703) 559122, Ext 2310)*

OCTOBER 1980

6-8 Computational Methods in Nonlinear Structural and Solid Mechanics [George Washington University & NASA Langley Research Center] Washington, D.C. *(Professor A.K. Noor, The George Washington University, NASA Langley Research Center, MS246, Hampton, VA 23665- Tel (804) 827-2897)*

NOVEMBER 1980

18-21 Acoustical Society of America, Fall Meeting [ASA] Los Angeles, CA *(ASA Hq.)*